MADRAS FISHERIES DEPARTMENT

Bulletin No. 13

ADMINISTRATION REPORT, 1919-20

BY

THE HON'BLE MR. A. Y. G. CAMPBELL, C.I.E., C.B.E., I.C.S.

REMARKS ON CANNING

AND

MANUFACTURE OF FISH OIL AND GUANO

BY

SIR F. A. NICHOLSON, K.C.I.E.

Reports Nos. 1, 2 and 3 of 1921.

MADRAS

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Report No. 1 (1921).

ADMINISTRATION REPORT OF THE DEPARTMENT OF FISHERIES, MADRAS, FOR THE YEAR ENDED 30TH JUNE 1920

BY

THE HON'BLE MR. A. Y. G. CAMPBELL, C.I.E., C.B.E., I.C.S.,
DIRECTOR OF FISHERIES.

ADMINISTRATION.

1. *Personnel.*—Sir Frederick Nicholson, who had handed over charge of the department to Mr. Hornell on 26th November 1918, continued in charge of the west coast fisheries stations until the 1st February 1920, when he finally severed his connexion with the department.

2. Sir Frederick Nicholson may be regarded as the founder of the Fisheries Department in this Presidency. It owes its inception and its success to his suggestions and supervision. In 1899 when he was a member of the Board of Revenue, he drew attention to the importance of studying and developing fisheries in this Presidency. In 1904 when the Government were about to take action on this suggestion, Sir Frederick Nicholson, who had by that time retired, offered his services for two years, one to be spent in carrying out a survey of fisheries in India and the other in the study of methods in Europe. The offer was accepted and Sir Frederick Nicholson entered on his duties on the 1st July 1905. In his report embodying the results of his enquiries on the west coast, he laid emphasis on the restricted exploitation of the sea, the inefficiency of the boats and nets, the difficulty of landing catches in a sound and untainted condition and the treatment of fish when landed. After the submission of his report he visited Japan, the United States and England in 1906 and he made another extensive tour in America and Europe in 1907. He then formulated the following proposals:—

(1) The establishment of an experimental station at Ennore with a view to design new and better boats and nets, to experiment on improved methods of fishing and curing, and to study the habits, movements, food, etc., of the fish and the economics of the industry and trade.

(2) The establishment of another station on the west coast to improve the salting and drying, the smoking and the canning of fish, and the manufacture of fish-oil and guano.

(3) An oyster laying ground near Ennore.

(4) The utilization of inland waters for fish-hatcheries.

These proposals were sanctioned by the Government.

3. In 1908 work was begun at Ennore, but it was impossible to make satisfactory experiments owing to the poor supply of fish, the small numbers and the poverty of the fishermen, and the absence of any local curing industry. An oyster farm was established in 1908–09 at Pulicat and is still in existence. In November 1909, an experimental station was opened at Cannanore and experiments were undertaken in the use of salt brine for preserving fish, in ordinary curing, salting and drying of fish and in the manufacture of fish-oil and guano. In 1910–11, preparations were made for starting canning, but in the following year the experimental station was removed from Cannanore as the fish were not very abundant. Curing operations and the manufacture of fish-oil and guano were transferred to Tanur where they are still carried on. The large number of fish-oil and guano factories which have now been established on the west coast is the direct result of the work at Tanur. Canning operations were first removed to Calicut but in 1914–15 the cannery was moved to its present site at Chaliyam.

4. Researches to overcome the difficulty of obtaining first-class oil for canning led incidentally to the establishment of the soap factory which is now under the Department of Industries. The outbreak of war interfered with the development of the department and especially with the branch relating to deep sea fishing. Proposals were however made for the establishment of a new aquarium and of a pearl oyster farm and a marine biological station on Krusadai island off Ramnad district.

5. The control of the pearl and chank fisheries was transferred to the department from April 1909.

6. As regards fresh-water fish, it may be mentioned that trout have been introduced into the Nilgiris; fish farms have been established at various places in the Presidency from which tanks and rivers can be stocked every year; larvicidal fish have been bred in large numbers and distributed; a live fish market has been established in Kurnool and a beginning has been made of the systematic stocking of tanks which is to be extended in time throughout the Presidency.

7. Sir Frederick Nicholson found that socio-economic work amongst the fisherfolk was necessary in order to enable them to get and keep out of debt before they could adopt improved methods of catching and dealing with fish. This branch of the work which includes education and temperance as well as co-operative work has made considerable progress on the west coast.

8. A large number of valuable bulletins has been issued by Sir Frederick Nicholson or under his direction.

9. In 1920 the designations of the Marine Assistant, the Assistant Director and the Piscicultural Assistant (Lieut. J. H. Allan, Mr. V. Govindan and Mr. B. Sundara Raj, respectively) were changed to Assistant Director of Fisheries (Marine), Assistant Director of Fisheries (Coast) and Assistant Director of Fisheries (Inland). The new titles indicate generally the different spheres of their work. The Assistant Director of Fisheries (Marine) is mainly concerned with sea fisheries including the pearl and chank fisheries and the maintenance of the fish farm at Tuticorin. The Assistant Director of Fisheries (Coast) deals generally with fish after it is landed (e.g., fish-curing, the manufacture of fish-oil and guano and measures to be adopted for marketing the fish, etc.); he also deals with fishermen, and especially carries on socio-economic, temperance and educational work amongst them. The Assistant Director of Fisheries (Inland) deals with problems regarding fresh-water fish, including the breeding and distribution of larvicidal fish in connexion with anti-malarial operations. The Marine Biologist is concerned with the identification of marine fauna and the supply of marine biological specimens to educational institutions and museums.

10. *Headquarters office.*—A portion of the building belonging to the Bank of Madras in the Mount Road, Madras, had been temporarily placed at the disposal of the Director of Fisheries until the branch of the bank should be opened there. This building had to be vacated on 1st December 1919; the office was then transferred to No. 1, Smith's Road.

11. Information regarding the personnel of the staff and the tours of the Director will be found in Statement No. I appended.

General.

12. *Expansion of work.*—In July 1919 the Government appointed a committee to consider the question of constructing a steam trawler which could be used for the purposes of pioneering steam-trawling, for visits to the Laccadives and for the inspection of light-houses and ports. The committee reported during the year and the orders of Government are awaited. No further progress was made for the project of the construction of a new aquarium and laboratories at Madras. The Public Works Department began the repairs of the Ennore bungalow which is required as a fishery station in connexion with inland fisheries as well as the development of the oyster and other fisheries in the backwaters in the neighbourhood. Mr. Hornell submitted proposals for the establishment of a fisheries college; the proposal is still under the consideration of Government. The expansion of various branches will be dealt with in later paragraphs.

13. *Finance.*—A summary of expenditure and receipts of the Fisheries Department (Statement II) shows a net loss of Rs. 19,086 as against a net profit of Rs. 42,026 in the previous year. The difference is due to a fall by Rs. 40,000 in the receipts under 'marine fisheries' and Rs. 10,000 in the receipts under 'factories.' There was also a rise of Rs. 27,000 in the expenditure under the head 'supervision and research' and of Rs. 2,200 under 'vessels'. On the other hand there was a fall in the expenditure of Rs. 10,000 under 'marine fisheries' and of Rs. 7,000 under 'factories.' The increased cost under 'supervision and research' was due to the larger staff employed including the Marine Assistant and the Marine Biologist. Other variations will be dealt with under their respective heads in later paragraphs.

Coast Section.

14. *Personnel.*—Sir Frederick Nicholson finally handed over charge of the west coast work on 1st February 1920. Mr. Govindan was then placed in charge of the following items of work :—

(1) the experimental fish-curing yard at Tanur ;
(2) co-operation ;
(3) educational, temperance and other socio-economic work ;
(4) fish-oil and guano operations, including the supply of fish-oil to the Board of Munitions ;
(5) fish-curing yards ; and
(6) inshore fishing experiments at Madras.

15. *Tanur experimental yard.*—The season was poor as regards the supply of the larger kinds of fish, but sardines were plentiful for several weeks and prawns were available in fairly large quantities ; no mackerels were available at all. Altogether 127,476 lb. of fish costing Rs. 3,542 were cured and sold for Rs. 5,818. In the oil and guano operations 260 tons of sardines costing Rs. 2,321 were treated and yielded 585 gallons of oil and 44½ tons of guano. The sale-proceeds of the oil and guano amounted to Rs. 4,568, leaving a stock in hand valued at Rs. 656. The highest price realized for guano was Rs. 115 per ton *ex* factory, Tanur. The oil and guano operations resulted in a good profit in spite of the fact that the fish were much leaner than in previous years and the percentage of oil was consequently much less than usual, not amounting even to one per cent.

16. An experiment in the sharp freezing and chilling of fish was tried, but it was not a commercial success owing to the large quantity of ice required and its exorbitant price Further experiments will however be made with the co-operation of the railway companies with a view to place quantities of cheap fish on the markets in the interior at long distances from the coast.

17. A considerable quantity of fish oil of a superior grade was supplied to the munitions factories and to private manufacturers. Several consignments of guano were also purchased and supplied to co-operative societies and others.

18. Samples of fish oil were sent to the Indian Institute of Science, Bangalore, for experiments with a view to find out the simplest and the least expensive methods of reducing their acidity.

19. As enquiries were made for fish meal for feeding cattle, pigs and dogs experiments were made in its preparation. Samples prepared have been favourably reported on as regards their quality and further experiments on a larger scale will be conducted during the coming season.

20. The Tanur trading accounts which are appended show a gross profit of Rs. 946 and a net profit of Rs. 53.

21. *Co-operation.*—The number of fishermen's Co-operative societies rose from 31 to 47 of which 41 were on the west coast and 6 on the east coast. The membership rose from 1,900 to 2,827. The number of shares and the paid-up share capital rose from 2,438 and Rs. 25,388 to 3,832 and Rs. 49,232 respectively. The loans disbursed amounted to Rs. 1,17,520 as against Rs. 40,511 in the previous year. Applications for registration from 13 societies organized during the year were pending at its close. The oil and guano wholesale co-operative society at Mangalore had 36 factory owners as its members and their output of manufactured goods was about 850 tons of guano and about 200 tons of fish oil valued at nearly Rs. 1,10,000. For want of proper organization it was not possible to effect a joint sale of all their output, but the commission collected by the panchayat on the sales amounted to nearly Rs. 2,000. The societies have on the whole worked satisfactorily, if due allowance is made for the inexperience and illiteracy of the great majority of the members.

22. Proposals to arrange for the transport of fresh fish into the interior towns and villages by means of motor lorries are under consideration especially in South Kanara. A similar proposal to bring fresh fish into Madras by motor-lorry from Covelong and other villages in that neighbourhood is also under consideration.

23. *Education.*—The Government fisheries training institute was opened on 14th July 1919 at Calicut. The object of the institute is to train teachers for elementary schools for fisherfolk. In addition to the training in pedagogy, arrangements were made to familiarise the pupil teachers with technical work carried on in the fisheries stations at Tanur and Chaliyam. A boat has been purchased and a fishery instructor has been appointed to instruct the pupils in fishing.

24. At the beginning of the year the Government sanctioned the opening of eight elementary schools for fisherfolk on the west coast. At the end of the year ten day and ten night schools were maintained on the west coast by the department. There were 565 pupils in the day schools and 364 in the night schools making a total of 929. Seventeen of the schools were newly started during the year under review. In some cases the schools were started by the villagers themselves and handed over to the department after they had worked them two or three months and proved the need for such schools in their villages; in other places schools were opened by the department on the receipt of applications from the fisherfolk. As far as possible local men are appointed as honorary managers of these elementary schools and some of the local managers have rendered valuable service. Most of the schools are accommodated in temporary sheds and more permanent buildings are urgently required.

25. *Temperance and socio-economic work.*—The temperance society at Mangalore and its branches have done good work. Sites for constructing village halls in Malpe and Kaup have been granted by the Collector of South Kanara and nearly Rs. 3,000 have been collected by the fisherfolk themselves for the construction of the buildings. The fisherfolk at Kizhur in South Kanara constructed a building in which their meetings are held and the fisheries elementary school is located. An indigenous temperance organization at Nadukuppam in Madras was helped to reorganize its work. Assistance was given to the Arya Young Men's Association of Rayapuram, Madras, which had organized a reading room. Propaganda was carried on in the Chingleput and Nellore districts. Proposals have been submitted to the Government for additions to the staff of sub-assistants in order to carry on the work all along the east coast.

26. *Oil and guano manufacture.*—This industry has continued to make rapid progress. The number of private factories increased from 358 to 563. It is estimated that 24,000 tons of guano valued at Rs. 100 per ton f.o.r. were manufactured during the season. Unfortunately most of it was exported, especially to Japan. The value of oil manufactured was about Rs. 3,75,000. The insanitary conditions of the factories referred to in paragraph 27 of Sir Frederick Nicholson's report for last year were not remedied, but the rules referred to by him have since been issued. In some localities factories have become too numerous. Adulteration of guano with sand or mud has become an almost universal practice and in some samples of guano 25 per cent of sand has been detected. The remedy for this adulteration must for the present be in the hands of buyers who do not pay sufficient attention to the quality of the guano they buy. Adulteration can only be checked when they decline to accept inferior qualities and are prepared to pay a good price for the pure article.

27. The season for sardines was generally good, but as the fish were very lean, the percentage of oil obtained was low. The price of fish rose owing to the competition between the factories. A basket of sardines which used to be sold for from 4 to 8 annas in previous years fetched as much as Rs. 1-8-0. This is beneficial to the fisherfolk, but necessarily reduced the profits made by the factory owners.

28. During the year 24,557 gallons of various grades of fish oil were purchased and supplied to the Board of Munitions. Most of it was of a superior grade and had to be specially manufactured in a few factories where the manufacture could be supervised. The factory owners were however reluctant to bestow the extra care and labour and to adopt the cleanliness required to produce superior grades of oil, even though they were paid high rates; consequently it was not possible to supply all the oil required by the Board of Munitions.

29. *Fish-curing yards.*—In the 7 yards on the west coast managed by this department during the year 204,117 maunds of salt fish were cured and 60,061 maunds of salt were supplied free of duty. The object of taking over these yards was to introduce certain improved methods which have been tried successfully at the Tanur experimental yard. The construction of better ventilated curing-sheds with cemented floors, drainage, etc., has been undertaken by several ticket holders in the Malpe and Mangalore yards but has been postponed in yards in Malabar on the ground of poverty. Among other improvements may be mentioned the use for curing fish of old brine after it has been filtered. Nearly 3,000 gallons have been used in the Thalayi yard, and other yards are being provided with filtering apparatus; this method should reduce the quantity of salt issued for fish curing. The practice of drying fish on tatties raised above the ground is also being introduced so as to dry fish more quickly and to prevent the admixture of sand and dirt with the fish which results from the ordinary practice of drying the fish on mats spread on the sand.

30. Several applications for opening new yards were received during the year and the opening of seven was sanctioned, but difficulty has been found in securing suitable sites.

31. The staff of the fish-curing yards was strengthened by the appointment of a reserve yard officer to relieve sub-inspectors when they go on leave and by the appointment of four assistant yard officers for eight months in the year to assist the sub-inspectors during the busy season.

32. *Inshore fishing experiments, Madras.*—The object of these experiments is to ascertain whether better results can be obtained with Malabar boats and various appliances than with the local

catamarans and appliances. They were continued with four Malabar canoes and various kinds of nets, long lines, etc. The full crew of 21 hands worked for 6½ months, while for the remaining 5½ months the crew was reduced to from 9 to 15 men. In 310 working days 114,850 lb. of fish were caught and sold for Rs. 6,404; average daily catch was 370 lb. valued at Rs. 20–10–6. The capital outlay on boats and nets was estimated at Rs. 1,500. The fishing season was not favourable. The Malabar boats were able to go out to sea on several occasions when the local catamarans could not be taken out on account of bad weather. The total expenditure during the year was Rs. 6,377 including a capital outlay of Rs. 270. The expenditure was high on account of the large increase in the cost of provisions for the crew; moreover the department had to incur an expenditure of about Rs. 1,320 on account of house-rent, the pay of an overseer and a cook which would not have been incurred, had this fishing been undertaken by local fishermen. It is clear therefore that fishing on these lines is very profitable. Enquiries have been received from more than one person who wishes to take over the business. The transfer of the business to one of the applicants has been recommended to Government and the orders of the Government are awaited. Proposals for extending the experiments to other important fishing centres such as Cuddalore and Negapatam are under consideration.

Marine Section.

33. *Chank fisheries.*—The returns from the chank fisheries were not as satisfactory as in the previous season. The labour problems presented difficulties and the weather was more unfavourable. A profit and loss account is appended. The profit was Rs. 46,029 as opposed to Rs. 82,611 in the previous year which was the highest on record.

34. *Tinnevelly chank fisheries.*—The divers of Tuticorin with the assistance of local capitalists who wished to employ them at the Ceylon chank fishery in February struck work at the beginning of the season, i.e., in October, and demanded increased rates of payment for chanks. The demands were refused and divers were brought from Kilakarai who worked regularly until the 2nd March 1920 when a local diver was bitten by a shark and died. This is the first time in the annals of the Tuticorin fishery that such an incident happened and the divers refused to work for several days. The Government sanctioned the payment of a gratuity to the family of the deceased diver. The total catch amounted to 158,941 full sized chanks, as against 148,285 in the previous year. The average earnings per diem per head during the 132 days of the fishery were Rs. 1–9–0 while the average daily earnings per head during the fishery season taken as a whole were Rs. 1–2–0.

35. Owing to the failure of the contractors for the purchase of the shells to pay the value of the Tinnevelly and Ramnad shells for the season 1918–19, the Government sanctioned the filing of a suit for its recovery ; the total amount recoverable was nearly Rs. 1,36,000.

36. *Ramnad chank fishery.*—The season was poor, the total shells taken being 180,894 as against 286,977 in the previous year. The poor results were due to the shortage of the labour supply, as the Kilakarai merchants took all the available divers to Ceylon to work in the chank fishery there. The weather was also unfavourable, as the divers had good fishing on only 48 days out of the 74 during which the fishery lasted. The maximum number of divers who worked in the fishery was 200 as against 400 in the previous year. Out of 19,571 undersized or immature shells fished at Rameswaram 13,813 were returned alive to the sea in $1\frac{1}{2}$ fathoms of water close to the shore. Within a period of three or four months, shells of about 2″ in diameter grew by $\frac{1}{4}''$ and $\frac{3}{8}''$. This helped the local divers a great deal as they were able to fish these shells by wading in the sea in July and August, when they could do no fishing of any kind on account of the south-west monsoon. On account of the shortage of labour about Rs. 4,000 were saved on account of towage. The small diving force at Vedalai sustained a loss of five divers on account of an outbreak of cholera. The fishery at Tirupalakudi was seriously affected by the influx of fresh water brought down by the Vaigai during the rains which caused the sea water to remain turbid during the best part of the season. No Valampuri shells were obtained during the season under report.

37. *Sivaganga chank fishery.*—The Sivaganga fishery yielded 3,036 shells as against 2,266 in the previous year. The gross proceeds were Rs. 306 and the charges including the rental paid to the Sivaganga estate amounted to Rs. 286 leaving a net profit of Rs. 20 as against Rs. 100 in the previous season. The decrease in profit is due to the reduced price for which the shells were sold. The shells were all caught in nets, the attempt made by the department to fish the beds with the help of the divers not being successful.

38. *Tanjore chank fishery.*—Rs. 1,822 out of the rental of Rs. 5,922 due for 1917–18 became irrecoverable as the contractor had neither movable nor immovable property.

39. *Ceylon chank fishery.*—No expedition was sent to Ceylon during the year under review. The chanks fished in Ceylon in 1918 were left unsold on account of the low prices offered and they were sold during the year under report for Rs. 140 per 1,000 full-sized chanks. The gross proceeds amounted to Rs. 7,274 ; deducting the expenditure of Rs. 4,649, the net profit was Rs. 2,625.

40. *Advances to divers.*—In accordance with G.O. No. 3948, Revenue, dated 13th December 1918, the Assistant Director of Fisheries (Marine) is allowed a temporary advance of Rs. 8,000 for chank fishery operations for (1) purchase of chanks, (2) contingent expenditure and (3) grant of advances to divers during the chank fishery season. I found that a large amount of this advance was not refunded to the treasury at the end of the season and that this was due to the fact that the divers owed to Government a considerable amount on account of advances which have not been refunded. I investigated this question therefore in some detail during my inspections at Tuticorin, Rameswaram, etc.

41. In recent years it has been the custom to give divers advances in accordance with the usual practice among merchants. These advances should be recouped from the earnings of the divers. A statement (No. VII) is appended showing the amounts of advances made in each year to the Tinnevelly, Rameswaram, Tirupalakudi and Kilakarai divers respectively and the amounts recovered. It will be seen that the practice began in the year 1909 when Rs. 112 were advanced to Tuticorin divers and only Rs. 8 were recovered. Advances were made to the Tirupalakudi and Kilakarai divers first in the year 1914–15 and to the Rameswaram divers first in the year 1916. The total advances issued amounted to Rs. 15,216–1–1 of which Rs. 11,598–0–6 have been recovered leaving a balance outstanding at the end of last season of Rs. 3,618–0–7. Advances have been occasionally written off as irrecoverable on account of such circumstances as the death of the divers from whom they were due. I found that in certain cases the accumulation of advances was due to unsuccessful fisheries organized by the Government; and it appeared to me that in such cases the Government and not the divers should bear the loss which was due to the failure of experiments made by the Government. I have recommended to the Government that the amount of Rs. 952–1–3 should be remitted on this account. As the total advance outstanding on this date is now reported to be Rs. 3,226–8–8, this leaves a balance of Rs. 2,274–7–5. The Assistant Director of Fisheries (Marine) hopes to recover this amount from the divers when paying the value of chanks to them during the ensuing season.

42. This practice of keeping divers in perpetual debt to the Government is, in my opinion, objectionable and should be stopped. If the fisheries fail, the advances made to divers should be written off as the divers are paid only by results according to the number of chanks which they recover and do not receive any daily wages, but the figures appear to indicate that advances have been given without due consideration to the probability of their recovery in the

ordinary course from the divers. I have not submitted further proposals in this connexion to the Government, because it seems to me that it should be better dealt with by Mr. Hornell on his return from leave, as he may have personal knowledge of the circumstances in which the advances were made. But I am inclined to think that every year at the close of the season the advance account should be closed and any amounts which have not been recovered from the divers and cannot be recovered from them should be recommended to the Government to be written off as irrecoverable with a full explanation in each case of the reason why the advance was not recovered.

43. It appears to me that instead of following the usual practice of making advances to divers and so keeping them in perpetual debt to the Government, it would be better for the Government to win the gratitude and willing service of these fishermen-divers by paying more attention to their well-being in various directions. I have therefore called upon Mr. Govindan, the Assistant Director of Fisheries (Coast), to organize in consultation with the Assistant Director of Fisheries (Marine) socio-economic work amongst them as soon as possible. We should in my opinion do among them such work as has been undertaken on the west coast amongst the fisher-folk, that is to say, we should establish day schools and night schools where they are not already established and should encourage temperance and take other measures to free them from debt not only to the Government but also to others.

44. *Bêche-de-mer fishery.*—This fishery which is carried on at Tirupalakudi in Ramnad district resulted in 6,245½ lb. of a cured product as against 3,038 lb. in the previous year. The *bêche-de-mer* were plentiful until the rains set in, but the divers were unable to go out to sea on many days on account of the weather and the turbidness of the water. The fall in the exchange adversely affected the price which could be obtained at Singapore and it was decided to keep our stock unsold for some time till the market improves. Attempts are being made to get into direct touch with merchants in China.

45. *Inspection of pearl banks.*—The Tholayiram and Athombathu bars were inspected in February. The former is the largest pearl bank in Tinnevelly district. There were a few young oysters of 2″ diameter on the average, their age being approximately two years. The oysters taken were found to be healthy but there were no pearls in those opened. The number of square yards to one pearl oyster was 9·8. The progress of these oysters will be carefully observed and recorded. Further inspection was not possible owing to the weather and further inspection will be necessary this season as soon as the *Lady Nicholson* has been refitted with engines.

46. *Fishing experiments.*—Experiments were made on a small scale with seine and trammel nets at Tuticorin. Two nets were made locally and tried with the help of the crew of the Fisheries vessels during the off-season, but the results were indefinite as the experiments were not conducted systematically, the services of the crew not being available during the chank season. Similar experiments in the use of a long line with many hooks were indefinite for the same reason. Two Ratnagiri *machwas* were sent to Tuticorin from the west coast, but the Ratnagiri men, who were paid fixed daily wages, refused to fish beyond Hare Island. If the experiments with these *machwas* is repeated, I think that the crew should be paid partly by a share in the proceeds of the fishing.

47. *Tuticorin fish farm.*—The works in connexion with this farm were completed during the year. The sluice and weir were handed over to the Department of Fisheries on 26th September 1919 by the Public Works Department. On 22nd March 1920 the beach between the farm and the sea was breached by the sea owing to high tides and the farm was rendered useless. It will require a considerable sum to restore the farm to its condition when handed over and I am myself doubtful whether it is advisable to repeat the experiment on the same lines. I am inclined to think that it will be advisable to confine the farm to the inner lagoon leaving the outer lagoon open to the sea. The works between the outer lagoon and the inner lagoon will not be exposed to the same force as the sea beach between the outer lagoon and the sea. I have however left the matter to lie over till Mr. Hornell's return. The Deputy Commissioner of Salt has at my request kindly consented to give advice regarding the construction of fish farms as the problems involved in their protection and in the admission of salt water into and the drainage of salt water from fish farms is similar to the corresponding problems involved in the preparation of a site for a salt factory. The experience of the Salt Department is therefore likely to be valuable to the Fisheries Department in this respect.

48. *Fisheries vessels.*—The *Lady Nicholson* is still without engines, but is otherwise in good order. Proposals were made by Lieut. Allan to render her more stable and these are still under consideration as well as the proposals for refitting her with new engines. During the inspection of pearl banks the *Lady Nicholson* had to be towed by the motor launch *Leverett*. The *Leverett* was also engaged at Rameswaram in towing canoes in connexion with chank fisheries. Proposals for altering the *Leverett* so as to make her more sea-worthy were under consideration. The two small launches the *Sutherland* and the *Pearl* were used for towing canoes in connexion with the chank fisheries, the former at Tuticorin and the latter at Rameswaram. During the chank off season the *Pearl* was placed at the

disposal of the Marine Biologist for use in connexion with the collection of plankton and scientific investigations.

Orders were given to break up the *Turbinella* as it could not be repaired except at a prohibitive cost and a satisfactory price could not be obtained for it if sold. Proposals were submitted to the Government for the purchase of another sea-going launch at an estimated cost of Rs. 20,000 to carry on fishing experiments (notably seine-netting, long-lining and drift-netting), to tow canoes in connexion with the chank fisheries and to patrol during pearl-fisheries.

Marine Biological Work.

49. *General.*—Mr. Whitehouse, who joined the appointment of Marine Biologist in September 1919, carried on work in Tuticorin where accommodation for his office and laboratory has been rented, but it has not been possible to organize a well-fitted laboratory there hitherto.

50. The work falls into two divisions:—

(1) the investigation of biological questions relating to fisheries; and

(2) the supply of zoological specimens to educational institutions and museums.

51. *Investigation of biological questions.*—Specimens of fishes were identified and kept as a beginning of a type-collection. The difficult question of ascertaining the species of mullet found at Tuticorin was taken up and much work has been accomplished, but no announcement can be made at present. Very few species of mullets can be determined at sight; numerous measurements and close examinations are necessary in order to determine accurately the exact species of a given specimen; the literature is scanty and indefinite. Several authorities have undertaken to assist in the determination of species including Dr. M. E. Callinge of St. Andrews, Scotland, Dr. M. T. Elliot of Birmingham and Dr. Chaudhari and Dr. Baini Prashad of Calcutta. Occasionally materials were received for identification from other sources.

52. *Supply of zoological specimens.*—This work is extending rapidly. Specimens have been supplied not only to colleges in all parts of India but also to the University of Aberdeen. Many appreciative remarks have been received regarding the specimens supplied. The work was however hampered owing to the difficulty in obtaining glassware and other requisites, but it is hoped to make arrangements before long for the regular supply of containers and formalin, etc. This work is self-supporting as the specimens are

paid for. Later when the equipment and accommodation are improved and the staff is more fully trained, it is hoped to be able to take up injections, display of dissected specimens, skeletal preparations, and microscopical sections and mounts.

53. *The Marine Aquarium.*—The number of visitors to the aquarium was 163,517 as against 96,957 in the previous year. The admission money collected amounted to Rs. 9,380–4–0 as against Rs. 3,783–4–6 in the previous year. The expenditure incurred on the aquarium amounted to Rs. 4,861–5–3 as against Rs. 2,063–14–6 and the profits amounted to Rs. 4,518–14–9 as against Rs. 1,719–6–0. The additional expenditure has therefore been fully justified. The increase in expenditure was due to the improvements in the aquarium and charges for advertisements and for the supply of electric current. Since 29th November 1919 the aquarium has been open in the evenings, electric light having been installed. The number of persons admitted during the evening hours amounted to 7,280 and the collections during those hours amounted to Rs. 1,821–8–0. The largest attendance in a single day was on Pongal (16th January 1920) when 4,104 people visited the aquarium. It is hardly necessary to state that the number of visitors and the amounts collected are in far excess of the figures in any previous year ; the aquarium has been much more highly appreciated by the public and of more use for educational purposes, and there can be little doubt that this is due to the measures taken by Mr. Hornell.

54. The new guide to the aquarium written by Mr. Hornell was placed on sale in October 1919 and 1,400 copies were sold by the end of February 1920. The guide was then revised and enlarged by Mr. Hornell and illustrated, but owing to the increase in price to 2 annas, it has not found so ready a sale as the old guide, only 566 being sold up to the end of the year; the average number of copies sold per mensem was 141 as against 350 of the first edition. The sale-proceeds of the guides amounted to Rs. 164–3–0 as against Rs. 24–11–0 in the previous year. A Tamil translation of the guide is under preparation.

55. A certain amount of research work is carried on in the aquarium. Detailed notes on the habits of fishes, crustaceans, etc., in the aquarium are recorded as well as data regarding the rate of growth, the spawning seasons, etc. The systematic identification of crabs at Madras and at Tuticorin has been undertaken. The causes of the death of fish in captivity are under investigation. The supply of dried specimens of crustacea was transferred to the aquarium from Tuticorin in November 1919. Arrangements are being made to exhibit on the wall-space available at the aquarium typical specimens of marine animals preserved in fluid.

56. Proposals have been made to add a workshop and a laboratory to the aquarium owing to the lack of sufficient space for research and supply work and to provide a filter-well on the foreshore whence fresh sea-water can be pumped every day into the aquarium.

57. *Pulicat Oyster Park.*—The oyster season in 1919 closed on the 15th September 1919, whereas in the previous year it had been kept open till the 6th November. The season of 1920 opened on 15th March, whereas in the previous year it opened on the 17th February. The season was affected by rain which reduced the salinity of the water in the Pulicat lake. During the year under report 133,450 oysters were supplied as against 404,850 in the previous year. The receipts and expenditure were Rs. 1,715–9–6 and Rs. 1,860–0–6 as against Rs. 1,930–13–3 and Rs. 1,820–15–3 in the previous year. There was therefore a loss in 1919–20 of Rs. 144–7–0 as against a profit of Rs. 109–14–0 in the previous year. The loss is ascribed to the short period when the oysters were in suitable condition for the table, and the increase in freight and carriage. I had enquiries made in the middle of the current season as to whether the oyster trade was paying or not and the conclusion arrived at was that it is being worked at a loss. It seemed undesirable to raise the prices for the last two months of the season, but it appears undoubted that the prices will have to be raised next season. Pulicat is 15 miles from the nearest railway station. When the Fisheries bungalow which is now under repair by the Public Works Department at Ennore is returned to this department, it may be possible to establish oyster farms in that neighbourhood.

Experiments to determine the biological conditions conducive to the healthy life of oysters were made in the aquarium, and others to ascertain the period of spatfall, the rate of growth, etc., were in progress at Pulicat. A scheme of cultural experiments including the trial of various artificial foods has been drawn up and these will shortly be undertaken at Ennore.

INLAND FISHERIES.

58. *General.*—In April 1920 the Government sanctioned the increase of the permanent staff by four assistant inspectors, two overseers and two fieldmen. Hitherto the posts have been temporary and difficulty has been experienced in obtaining the services of suitable men.

59. Fresh-water pisciculture is being extended district by district. In February 1920 the Government approved of the acquisition and organization of all suitable tanks in the Chingleput and Nellore districts and sanctioned a capital expenditure of

Rs. 4,000 and Rs. 7,600 and recurring charges of Rs. 1,538 and Rs. 4,044 respectively towards the execution of schemes. The District Boards of Chingleput and Nellore have been granted compensation at the rate of Rs. 2,300 and Rs. 7,000 per annum respectively on account of fishery rentals derived from the 25 and 110 tanks transferred to the control of this department. Ponds and sheds at the various breeding and stocking stations were under construction.

60. The receipts from inland fisheries amounted to Rs. 76,564 as against Rs. 77,297 in the previous year. The receipts exceeded the expenditure by Rs. 21,331 as against Rs. 20,573 in 1918–19. An inquiry was made as to the market-price of fish before the war in selected places in the Presidency and it was found that the percentage of increase in price varies from 30 per cent to 50 per cent. Assuming that the rise in the market-price of fish is 50 per cent, there is a margin of 20 per cent increase in the rentals as the increase over the compensation paid to local bodies (which is based on the average rentals for five years) works out at more than 70 per cent. From this it may be concluded that the stocking operations have resulted in an increase in the rentals and therefore presumably in the stocks of fish available.

61. *Fish-farms.*—At Sunkesula carp and *etroplus* were bred in the farm and distributed to the Cuddapah-Kurnool canal and to the selected tanks in the Ceded districts. The silting up of the Tungabhadra in the neighbourhood of the farm has caused great difficulties in obtaining an adequate supply of water during the dry weather. It is therefore desirable to transfer the fish-farm to another place. The sites finally selected are Praema and Mahanandi in Nandyal taluk. The scheme is under investigation by the Public Works Department. In the fish market at Kurnool, 509 lb. of murrel and 1,826 lb. of carp reared in the Sunkesula farm were sold for Rs. 334.

62. The *etroplus* introduced last year into the farm at Ippur in Nellore district bred on a large scale and it was possible for the first time to distribute the fry of this non-indigenous fish to the tanks served by this farm. The tanks were also supplied with mullets. About 12,600 larvicidal fish were supplied to local boards and private persons.

63. The general work of the powder factory farm at Madras was satisfactory, but owing to an unusual inundation during the rains a large number of murrel and fresh-water sharks managed to enter the breeding-pond despite the wire-net fence and destroyed a large number of the gourami fry bred this year. The pond has since been drained, the gourami being transferred temporarily to a private pond in the Hydari Gardens. After the predaceous fish had been

eliminated, the gourami were successfully returned to the pond. About 800 *etroplus* and 700 mullets were distributed from the fish-farm to twelve tanks in the Presidency.

64. The new larvicidal fish-farm at Praema in Kurnool district was brought into working during the year. This farm was constructed in 1917. An exhaustive list of perennial waters on the Nallamalais was obtained from the Forest Department and in February 1920 with their assistance 70,000 larvicidal fish were distributed to all the streams and pools in the Nandyal and Chelama forest ranges. Operations will be extended to other ranges next season when it is expected that the farm will grow a larger stock of fish.

65. *Acclimatization and artificial propagation.*—Gourami bred twice in Sunkesula and in the ponds of the powder factory, Perambur ; but as already indicated the normal crop of fry in the latter farm was not obtained. At present gourami are bred in ponds under natural conditions, but the authorities of Java have been addressed regarding an artificial process of breeding them on an extensive scale.

Etroplus suratensis bred prolifically in the artificial nests designed for them at Sunkesula and in the powder factory at Perambur ; they bred for the first time at Ippur. Complete success has therefore attended the acclimatization and cultural experiments started in the year 1915–16 and it will now be possible to distribute to fresh-water lakes and tanks this valuable estuarine food-fish which is usually confined to tidal waters along the coast.

The tench and English carp under observation in Sunkesula have continued to do well but have not yet bred.

A large stock of fry of *mugil troscheli* and other allied mullets were transferred to tanks and reports on water stocked last year and fished this hot weather show that success attended these experiments. Mullet fry ranging in size from 2 inches to 5½ inches have grown to 9 inches and 11 inches within a period of ten months in the Ippur fish farm.

One of the largest of the indigenous carp is *catla catla* ; this fish is very numerous in the Kistna, the Gōdāvari and rivers further north and is regarded as one of the valuable food fishes of these rivers. Half a century ago it was unknown in waters south of the Kistna. Since the opening of the Cuddapah-Kurnool canal and the stocking of that canal by this department with this species, this fish has found its way into the Pennar river and is now very common in tanks fed by the Pennar in Nellore district where it is known as Kistna botcha or Kistna carp. Last year a consignment of this carp was introduced into the Madurāntakam tank and it is proposed to extend this fish further south.

The hilsa hatchery at the Lower Anicut in the Cauvery river was operated from the 5th August to 22nd August 1919. Nine batches of ripe ova consisting of several thousands of eggs were successfully fertilized and hatched. The experiments since 1915 have enabled us to determine the correct process of artificially fertilizing hilsa eggs. The fry hatched are turned into the river two or three days after their birth. In order to attain an extra advantage from hatching operations, it is desirable to determine experimentally the process of rearing the fry up to the stage when they are better fitted to shift for themselves before placing them in rivers. At present the factors which determine the growth of the hilsa fry and their natural food are entirely unknown. Preliminary arrangements for the initiation of experiments were seriously handicapped by the scarcity of glassware and scientific apparatus, as well as by the want of facilities at the Lower Anicut. The floating hatchery scheme for the Colair lake in Kistna district was intended to replace the hatchery of the Lower Anicut, but private rights and stake nets continued to hinder the execution of the scheme.

An attempt to introduce thick-shelled river mussels from Bengal and Punjab in order to provide mussel shells suitable for the manufacture of buttons was unsuccessful.

The Palni Game Association propose to stock the waters of the Palnis with trout. A preliminary survey of the streams and lakes in the Kodaikānal plateau to determine their suitability for trout was undertaken by the Assistant Director in May. A suitable site for a hatchery cannot be selected until the temperature and other conditions of the streams from October to March—the breeding season for trout—are ascertained.

66. *Incomplete schemes.*—As the jungle road from Pallamadugu to Peddagadi was completed during the year by the Public Works Department, arrangements for breeding suitable larvicidal fish at Peddagadi in Cuddapah district will now be taken in hand. The arrangements were sanctioned in G.O. No. 1898 M., dated 2nd October 1918.

In September 1917, the Government approved of the combined fishery and anti-malarial scheme for the Chingleput fort moat. Detailed estimates amount to about Rs. 17,000. Their execution has not yet been begun.

In November 1918, the Government sanctioned the control and improvement of the Vellore fort moat by this department. The estimates for its improvement amount to Rs. 18,460. The work has not yet been begun.

In November 1918 the Government approved of a piscicultural scheme for the Mopad tank in Nellore district. The Public Works Department have been requested to arrange for the construction of the farm.

In May 1919 the Government sanctioned the fishing of the Kanigiri-Duvur reservoir. The detailed plans and estimates are under preparation by the Public Works Department.

67. All suitable tanks of the Ganjām district have been surveyed and a complete scheme for the organization of the fisheries is under preparation.

68. *Legislation.*—Considerable difficulty has been experienced in working out complete and comprehensive schemes for the waters of three districts (Chingleput, Nellore and Ganjām) and the Cauvery river owing to the existence of private fishery rights and to the varied and undetermined tenures of fishery rights obtaining in the different districts. For example Mr. Wilson's scheme for the establishment of a floating hatchery to breed artificially the most valuable of Indian herrings, the hilsa, in the Colair lake has been held up for the last seven years owing to the existence of stake nets in the Upputeru, as the smallest fry have no chance of escaping the numerous rows of small meshed stake nets. Proposals for the introduction of a Bill in the local Legislative Council for the determination and if necessary the acquisition of private fishing rights in the inland waters of the Presidency have been submitted to the Government.

69. *Co-operative movement.*—A notable feature of the year's work is the initial step taken towards the formation of co-operative societies amongst fresh water fishermen. The fishermen of certain villages on the bank of the Cauvery represented their inability to bid against rich Muhammadan gentlemen who purchase the fisheries of the Cauvery river in auctions and later sublease the fisheries to the fishermen for exorbitant sums, thus obtaining large profits at the expense of the Government and of the fishermen. The large communities of Oriya fishermen in Ganjām have agreed to form themselves into co-operative societies.

Government Fisheries Cannery, Chaliyam.

70. *General.*—Mr. H. L. Prager, Inspector of Salt and Abkari Department, was appointed business manager and took charge from Sir Frederick Nicholson on 5th December 1919. Though Sir Frederick Nicholson formally severed his connexion with the cannery, he continued to take a lively interest in it and was of great assistance to Mr. Prager.

71. *Machinery.*—Work was handicapped by the necessity of repairing some of the machinery. The swan-neck press for stamping lids and all the dies were sent to the Public Works Workshops,

Madras, for repair before Mr. Prager took charge and were not received back till the end of May. Tin plates had to be sent to Madras from the cannery to be stamped and returned in the shape of lids. Sardines had to be packed in 12 oz. cylindrical tins instead of in the usual rectangular tins and at times it was not possible to purchase all the fish brought in for want of suitably shaped cans or for want of any cans at all. To prevent a recurrence of this state of affairs, an additional lid-stamping press was made at the workshops for the cannery and a set of duplicate dies has been ordered from England. The industrial engineering branch of the Department of Industries should in future be consulted when necessary in connexion with defects in the machinery.

72. *Supply of fish.*—There was almost a complete dearth of mackerel, the fish most in demand. The supply of prawns was deficient, the greater number canned having been procured from Tanur. Sardines were generally very small and of poor quality and hardly worth canning. Difficulties were experienced in the matter of obtaining packing oils, firewood and charcoal.

73. *Output.*—In spite of these drawbacks 59,586 cans of all sorts were packed during the year as against 80,267 in the previous year. The opening balance was 37,683 and the number sold was only 40,729 as against 62,095 in the previous year, leaving a balance of 52,311 cans after allowing for over 4,000 cans packed but rejected when tested. The sales were appreciably affected by the cessation of hostilities and the consequent increased supply of canned goods from overseas, and by inability to comply with many orders for mackerel and prawns.

74. *Finance.*—The expenditure during the year amounted to Rs. 20,860 including Rs. 3,268 on capital accounts and Rs. 17,592 for running charges. The corresponding figures of the previous year were Rs. 34,285, Rs. 5,644 and Rs. 28,641 respectively. The total remittances into the treasury on account of sale-proceeds of canned fish, etc., was Rs. 18,644. The excess of drawings over remittances was therefore Rs. 2,216. The value of the cans in hand at the end of the year was Rs. 14,756.

According to the trading account, the gross profits for the year were Rs. 3,689 as against Rs. 8,465 in the previous year. Overhead charges (portion of Sir Frederick Nicholson's travelling allowance, 50 per cent of the pay and allowances of all the permanent staff including the manager, depreciation, etc.) are estimated at Rs. 5,497. There was therefore a net loss on the year's working of Rs. 1,808 as against a profit of Rs. 4,355 in the previous year. These figures have not been audited. The poor results are due to diminished outturn, fall in sales, loss on 8,708 tins of sardines of poor quality which were sold at less than cost-price under Sir Frederick

Nicholson's orders, the increased charges for supervision, the increased cost of fish and other supplies and the valuation of the balance of stock at only two-thirds of the selling price.

75. *Experiments.*—Not many experiments were attempted. Mullets which had hitherto not been canned were canned with success. Unfortunately, however, very few were obtainable and those only at prohibitive prices. It has been demonstrated that semi-dried prawns from Tanur can be safely canned as 'whole prawns' and can also be made into paste. A few tins of sardines with the scales (which consumers find a nuisance) removed were canned and were found to be a decided improvement, but the operation to remove the scales is tedious and expensive and the fish are liable to taint in the process.

76. *Machwas.*—The Ratnagiri machwas went out only for 30½ days. The catches were very poor and were sometimes delivered at the cannery and sometimes at Tanur. The total quantity of fish delivered to the cannery by these machwas was 3,096½ lb. valued at Rs. 124. The fishing from these machwas may therefore be regarded as a failure. As I have mentioned elsewhere, I am inclined to think that the practice of paying the crew fixed daily wages may have contributed to this result as the crew had no special inducement to bring in good catches.

General.

77. The staff have in almost all cases discharged their duties well and displayed a great interest in their work.

78. The usual statistics are appended.

A. Y. G. CAMPBELL,
Director of Fisheries.

13*th September* 1920.

STATEMENT I.—Staff of the Department of Fisheries, 1919–20.

Post.	Incumbent.	Period held.
Director	J. Hornell, Esq. ..	* 1st July 1919 to 14th January 1920.
Do.	The Hon'ble Mr. A. Y. G. Campbell.	† 15th January 1920 to 30th June 1920.
Marine Biologist ..	R. H. Whitehouse, Esq.	25th September 1919 to 30th June 1920.
Assistant Director (Marine).	Lieut. J. H. Allan ..	1st July 1919 to 22nd March 1920.
Do. ..	J. A. Fernandez, Esq.	23rd March 1920 to 30th June 1920.
Assistant Director (Coast).	M.R.Ry. Rao Bahadur V. Govindan Avargal.	1st July 1919 to 30th June 1920.
Do. (Inland).	M.R.Ry. B. Sundara Raj Garu.	Do.
Cannery Manager ..	H. L. Prager, Esq. ..	5th December 1919 to 30th June 1920.

* Was on tour for 77 days (including a visit to Rangoon for inspection of the *Sunbeam*), inspected the west coast stations and cannery, Ennore, Krusadai island, chank fisheries and fish farm at Tuticorin and visited Waltair in connexion with a proposal to open a cannery there.

† Visited Tanur, Chaliyam, Calicut and other places on the west coast, Tuticorin, Rāmēsvaram, Vedalai, Krusadai, Ennore and Pulicat.

STATEMENT II.—Summary of expenditure and receipts of the Fishery Department, 1919–20.

Particulars.	Expenditure.			Receipts.			Difference.			
	RS.	A.	P.	RS.	A.	P.		RS.	A.	P.
I. Supervision and research.	83,131	11	6	183	15	0	—	82,947	12	6
II. Marine fisheries.	63,581	2	1	1,07,855	15	0	+	44,274	12	11
III. Inland fisheries.	55,233	6	7	76,564	13	0	+	21,331	6	5
IV-A. Factories ..	32,214	12	2	35,360	6	10	+	3,145	10	8
IV-B. Vessels ..	10,637	3	2	6,909	0	4	—	3,728	2	10
V. Capital expenditure.	1,162	12	2	..			—	1,162	12	2
Total ..	2,45,960	15	8	2,26,874	2	2	—	19,086	13	6

Statement III.—Details of expenditure.

Particulars.	Capital expenditure.	Running expenditure.					Total.
		Salaries.	Establishment.	Allowances.	Supplies and services.	Contingencies.	
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
I. Supervision and research	5,536 2 11	24,535 0 8	26,225 3 7	16,751 9 9	7,965 12 2	7,654 1 4	83,131 11 6
II. Marine fisheries	2,400 12 5	5,200 15 6	11,471 5 2	2,080 1 6	41,829 2 8	2,999 9 3	63,581 2 1
III. Inland fisheries	1,791 3 10	897 8 0	1,434 9 8	..	52,901 4 11	..	55,233 6 7
IV-A. Factories—							
(a) Cannery	841 5 5	1,378 12 4	2,228 12 6	750 0 0	15,288 0 8	275 0 0	19,920 9 6
(b) Tanur	557 14 5	..	1,583 5 0	750 0 0	9,735 13 8	225 0 0	12,294 2 8
IV-B. Vessels	500 2 9	..	2,461 12 6	..	8,175 6 8	..	10,637 3 2
Capital expenditure (Total) ..	11,627 9 9	..	..	..	..	..	..
Depreciation and interest on above at 10 per cent. ..	1,162 12 2	..	..	..	..	..	1,162 12 2
Total ..	1,162 12 2	32,012 4 6	45,405 0 5	20,331 11 3	1,35,895 8 9	11,153 10 7	2,45,960 15 8

Statement IV.—Details of supplies and services. (Omitted.)

Statement V.—Details of receipts.

II. Marine fisheries.

	RS.	A.	P.
(a) Receipts from all chank fisheries including Bêche-de-mer fisheries as per statement VI ..	94,146	3	9
(b) Receipts from sale of zoological specimens ..	1,607	12	0
(c) Receipts from Pamban pearl farm.	54	4	0
(d) Receipts from Marine fish farm, Tuticorin ..	711	1	9
(e) Receipts from Marine Aquarium	9,380	4	0
(f) Receipts from oyster culture at Pulicat	1,715	9	6
(g) Miscellaneous receipts	240	12	0
	1,07,855	15	0

III. Inland fisheries.

	RS.	A.	P.
(a) Rentals from tanks and rivers, etc., the fisheries of which were taken over by this department—vide statement VIII.	75,956	3	6
(b) Receipts from Sunkesula fish farm	401	11	2
(c) Receipts from Ippur fish farm.	41	3	6
(d) Receipts by sale of larvicidal fish.	98	5	10
(e) Receipts from powder factory farm	9	5	9
(f) Miscellaneous receipts	57	15	3
	76,564	13	0

IV-A. Factories.

	RS.	A.	P.	RS.	A.	P.
A. Cannery—						
(1) Actual receipts (amount remitted into treasury) from sale of canned fish, etc.				18,643	13	6
(2) Amount outstanding—						
On 1st July 1920 ..	1,284	13	2			
On 1st July 1919 ..	1,853	3	10			
Difference ..				— 568	6	8
(3) Value of manufactured goods on hand—						
On 1st July 1920 ..	16,755	12	8			
On 1st July 1919 ..	12,773	7	5			
Difference ..				3,982	5	3
				22,057	12	1
B. Tanur—						
(1) Actual receipts				12,020	13	0
(2) Amount outstanding—						
On 1st July 1920 ..	1,193	5	3			
On 1st July 1919 ..	1,677	8	4			
Difference ..				— 484	3	1
(3) Value of goods on hand—						
On 1st July 1920 ..	2,069	9	6			
On 1st July 1919 ..	303	8	8			
Difference ..				1,766	0	10
				13,302	10	9

IV-B. Vessels.

	RS.	A.	P.
(a) Leverett.	..		
(b) Turbinella.	504	15	1
(c) Inshore fishing canoes.	6,404	1	3
(d) Machwas.	..		
	6,909	0	4

Note.—The sum of Rs. 183-15-0 noted against receipts under supervision and research represents the amount realized as rent from Ennore bungalow and sale-proceeds of fish caught in the experimental fishing conducted at Tuticorin.

STATEMENT VI.—Profit and Loss account of chank and bêche-de-mer fisheries for the season 1919–20.

Expenditure.	Amount. RS.	A.	P.	Receipts.	Amount. RS.	A.	P.
Chank fisheries—				Sale-proceeds of chanks fished—			
Tinnevelly	14,472	10	0	Tinnevelly	51,984	11	3
Ramnad	18,088	14	6	Ramnad	33,698	0	4
Sivaganga	286	3	0	Sivaganga	306	10	2
Bēche-de-mer fishery	1,779	0	1	Bēche-de-mer fished	894	1	2
Seventh year's proportion of the total consideration paid in 1913–14 for a fifteen years' lease of the Ramnad fishery ..	4,000	0	0	Chank rentals received—			
Supervision charges, pay and travelling allowance of Assistant Director (Marine), Sub-Assistant, etc.	9,490	2	1	Tanjore district	4,466	10	4
Balance being net profit	46,029	6	1	South Arcot district	1,546	2	6
				Chingleput and Nellore districts ..	1,250	0	0
Total ..	94,146	3	9	Total ..	94,146	3	9

STATEMENT VII.—Advances to chank-divers.

Season.	Tuticorin divers.		Rameswaram divers.		Tirupalakudi divers.		Kilakarai divers.	
	Issue.	Recovery.	Issue.	Recovery.	Issue.	Recovery.	Issue.	Recovery.
	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.	RS. A. P.
1909–10	112 0 0	8 0 0	..	..	..	..	..	..
1910–11	127 8 0	35 8 0	..	..	..	..	..	..
1911–12	223 4 6	334 8 6	..	..	..	..	..	..
1912–13	170 12 0	129 10 0	..	..	..	..	..	..
1913–14	430 0 0	458 14 0	..	..	..	..	..	..
1914–15	804 12 0	556 0 0	..	..	138 11 0	..	391 11 0	332 9 8
1915–16	315 10 0	597 8 6	16 14 0	..	109 0 0	95 11 6	1,497 7 6	754 6 10
1916–17	198 15 6	157 5 0	70 5 0	87 3 0	9 0 0	33 13 9	2,083 5 5	1,248 0 2
1917–18	421 4 6	265 7 0	110 4 0	76 14 0	40 10 6	31 14 11	2,820 15 10	1,983 3 5
1918–19	1,031 2 8	728 13 10	706 8 10	264 13 11	20 6 0	17 11 0	1,363 2 1	1,609 6 7
1919–20	817 4 0	571 1 2	5 0 0	96 9 8	26 10 0	23 1 6	1,153 8 9	1,029 13 5
Total ..	4,652 9 2	3,842 12 0	908 15 10	525 8 7	344 5 6	202 3 10	9,310 2 7	7,027 8 1

	RS.	A.	P.
Total advances issued	15,216	1	1
,, recovered	11,598	0	6
Balance outstanding ..	3,618	0	7

STATEMENT VIII.—List of tanks and canals stocked by the Fisheries Department with the compensation paid and rentals realized for the year 1919–20.

Name.	Compensation paid.			Rentals realized.		
	RS.	A.	P.	RS.	A.	P.
1. Cauvery and Coleroon ..	34,898	0	0	57,945	6	8
2. Kurnool-Cuddapah canal ..	2,553	14	0	3,342	6	0
3 Belegal and Badai Khan tanks	16	0	0	72	0	0
4. Markapur tank	95	0	0	170	0	0
5. Venkatapuram tank	..			35	0	0
6. Kocheruvu tank	..			16	0	0
7. Siddapuram tank	..			10	8	0
8. Kamalapuram tank	500	0	0	960	0	0
9. Daroji tank	155	0	0	216	10	8
10. Singanamalla tank	117	0	0	290	0	0
11. Godur and Karedu tanks ..	185	0	0	209	8	0
12. Ippur, Kamini and Puduparti tanks.	5	0	0	41	3	6
13. Chembarambakkam and Madurantakam tanks.	2,195	0	0	5,510	0	0
14. Dusi, Mamandur and Kaveripakkam tanks.	3,789	0	0	6,511	10	8
15. Barur and three connected tanks	120	0	0	187	0	0
16. Penukondapuram tank ..	118	0	0	125	0	0
17. Rangasamudram	200	0	0	Not auctioned owing to want of water.		
18. Tippasamudram						
19. Tsadam						
20. K. Vyasasamudram						
21. Peddinayudu tank	..			No sale.		
22. Panjampatti tank	..			25	0	0
23. River channels in Trichinopoly	..			288	14	0
24. Yellanur tank	..			..		
25. Barur tank	..			..		
Total ..	44,946	14	0	75,956	3	6

Statement IX.—Government Fisheries Cannery, Chaliyam, Trading account for the year 1919–20.

	RS.	A.	P.	RS.	A.	P.
To stock of canned fish on 1st July 1919 ..	9,683	0	6			
To stock of guano fish on 1st July 1919 ..	27	10	6			
To stock of fried oil on 1st July 1919	30	0	0			
To stock of prawn shells on 1st July 1919 ..	5	4	0			
To stock of pit manure on 1st July 1919 ..	20	0	0			
To stock of miscellaneous products	6	0	0			
To stock of empty cans manufactured in the cannery.	3,001	8	5	12,773	7	5
To cost of solder, tin-plate, empty-cans (imported), tin, rosin soldering fluid, turpentine, varnish, etc.	8,407	6	0			
To cost of fuel (firewood, coal, kerosene oil, petrol, etc).	1,094	14	3			
To cost of fish used for canning and curing ..	2,104	10	5			
To cost of fish condiments including oil for packing.	1,228	2	3			
To cost of sundry stores, such as soda ash, cotton waste, methylated and rectified spirits, vaseline, etc.	290	12	2			
To cost of salt and preservatives	105	13	8			
To cost of packing materials, such as packing baskets, brown, etc., papers, twine, straw, wire nails, etc.	661	7	5			
To cost of labels and rubberrings for tins ..	246	12	2			
Manufacturing wages—Wages of temporary staff and extra labour.	1,653	15	2			
Railway freight on parcels of canned fish and other goods and petty coolie and carriage.	2,574	10	8	18,368	8	2
Gross profit (transferred to profit and loss account).				3,689	3	11
				34,831	3	6

	RS.	A.	P.	RS.	A.	P.
By sale of canned fish remitted into treasury from 1st July 1919 to 30th June 1920.	17,469	8	0			
By sale of cured fish	577	7	1			
By sale of fried and rejected oil	87	13	0			
By sale of guano	275	0	0			
By sale of prawn shells	25	0	0			
By sale of tin scraps and empty kerosene tins, etc.	45	0	0			
By sale of miscellaneous articles	164	1	5	18,643	13	6
To amount collected and remitted into treasury of the previous year's sale.	....			1,853	3	10
				16,790	9	8
By value of canned fish, etc., sold but not realized and remitted into treasury on 30th June 1920.	1,284	13	2	1,284	13	2
By value of manufactured goods on hand on 1st July 1920—						
Canned goods	14,756	9	9			
Guano	14	4	7			
Pit manure	35	0	0			
Fried and rejected oil	6	12	0			
Fish oil	21	0	0			
Tin scraps and empty kerosene tins, etc.	7	8	0	14,841	2	4
By value of empty cans manufactured at the cannery on 1st July 1920.	....			1,914	10	4
				34,831	3	6

STATEMENT X.—Government Fisheries cannery, Chaliyam, profit and loss account for 1919–20.

	RS.	A.	P.		RS.	A.	P.
To fixed travelling allowance of Sir F. A. Nicholson, K.C.I.E. (12½ per cent only debited).	750	0	0	By gross profit transferred from trading account.	3,689	3	11
To pay of permanent staff, viz., manager, sub-assistant, mechanic, canning maistri, three clerks and one peon (50 per cent only debited).	3,020	8	2	Loss ..	2,089	4	3
To service stamps ..	278	0	0		5.778	8	2
To depreciation and interest at 10 per cent.	1,695	0	0				
To rent of Bangalore stall.	35	0	0				
	5,778	8	2				

STATEMENT XI.—Financial statement of the Tanur experimental yard for the period commencing from 1st July 1919 to 30th June 1920.

Trading Account.

	RS.	A.	P.	RS.	A.	P.
To stock of cured fish on hand on 1st July 1919.	37	8	0			
To stock of fish guano on hand on 1st July 1919.	4	10	8			
To stock of fish oil and foots on hand on 1st July 1920.	48	11	6			
To stock of prawn shells on hand on 1st July 1919.	100	2	6			
To stock of pit manure on hand on 1st July 1919	112	8	0			
				303	8	8
To charges:—(1st July 1919 to 30th June 1920)—						
To cost of fish purchased for curing.	3,541	4	9			
To cost of fish for oil and guano operations.	2,321	8	11			
Establishment wages (temporary) and wages of coolies on muster rolls, etc.	2,173	13	9			
Petty coolie and carriage	607	9	11			
Railway freight on cured goods	446	7	3			
Sundry stores	481	0	8			
Salt and preservatives	108	3	6			
Fuel	381	6	8			
Packing materials	748	12	0			
Saw dust	6	7	0			
Miscellaneous	40	1	0			
				10,856	11	5
To gross profit transferred to profit and loss account.	....			946	7	0
				12,106	11	1

	RS.	A.	P.	RS.	A.	P.
By sale of cured fish remitted into treasury from 1st July 1919 to 30th June 1920.	5,818	6	11			
By sale of fish oil and foots	30	10	9			
Do. fish guano	4,537	3	0			
Do. prawn shells	135	0	0			
	10,521	4	8			
Deduct outstandings shown in 1918-19 accounts.	1,677	8	4			
Balance ..				8,843	12	4
Add value of prawns supplied to cannery and adjusted in 1920-21 accounts.	....			847	15	1
Add value of goods sold but not realized on 1st July 1920.	....			345	6	2
By sale of stock on hand on 1st July 1919—						
Cured fish	243	4	0			
Fish guano	214	7	3			
Fish oil and foots	442	5	2			
Prawn shells	36	11	1			
Pit manure	136	8	0			
Expendible stores, e.g., salt, fuel, packing materials, etc.	996	6	0			
				2,069	9	6
				12,106	11	1

STATEMENT XI.—Financial statement of the Tanur experimental yard for the period commencing from 1st July 1919 to 30th June 1920—*cont.*

Profit and Loss Account.

Expenditure.

	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.
To rent paid for Bangalore stall at Rs. 5 per mensem.				60	0	0			
To rent of Cannanore yard paid.	50	0	0						
To rent amount due	10	0	0						
				60	0	0			
To postage charges				225	0	0			
To coconut plantation maintenance charges ..				64	4	9			
To pay of permanent staff (50 per cent) ..				965	0	0			
To supervision charges (Honorary Superintendent for 8 months at 12½ per cent).				750	0	0			
To depreciation on plant, etc. (Rs. 2,360−236+557-14-5)=2,681-14-5 at 10 per cent.				268	3	4	2,392	8	1
Net profit				....			53	7	3
							2,445	15	4

Receipts.

	RS.	A.	P.	RS.	A.	P.
By gross profit transferred for trading account.	946	7	0			
By collecting charges	1,117	14	5			
By miscellaneous receipts (coconuts, etc.). ..	261	9	11			
By rent of Cannanore yard	120	0	0			
				2,445	15	4
				2,445	15	4

NOTE.—Book value of expendible stores on hand were not included in the last statement In this statement this has been entered.

Order—No. 2278, Revenue (Special), dated 23rd December 1920.

Miscellaneous.	Recorded.

2. Sir Frederick Nicholson, the creator of the Fisheries Department in this Presidency, severed his official connexion with it during the year under report. The Government are glad to note however that he is still assisting the department with advice and by the writing of bulletins on special subjects connected with fisheries. The Director takes the opportunity in paragraphs 2 to 9 of his report of reviewing in very brief outline the past history of the department since its inception. There is hardly an important branch of work in the Fisheries Department which does not owe its existence to the originality and energy of Sir Frederick Nicholson, and for no less than fifteen years subsequent to his retirement Sir Frederick Nicholson's generosity has placed his services at the disposal of the Madras Government and the Madras public. The Government have already on more than one occasion recognized their debt to him in this matter and take the present opportunity of again thanking him for his services.

3. *General questions.*—The question of construction of a steam trawler which could be used for the purpose of pioneering steam trawling, for visits to the Laccadives and for the inspection of lighthouses and ports is still under the consideration of the Government. The committee appointed in July 1919 to consider the question estimated the cost of a steam trawler at £30,000, but the Consulting Naval Architect attached to the India Office has reported that a vessel of the description recommended by the committee would, according to the present rates, cost not less than £109,000.

Proposals for the purchase of an engine for 'Lady Nicholson' and of a new sea-going launch are under correspondence with the India Office.

4. The question of oil and guano manufacture is dealt with in paragraph 26 of the report. The pioneer work done by the department has long since developed into a private industry of some magnitude and the year under report shows a great further expansion. Unfortunately this expansion has been accompanied by dishonest adulteration. The question of legislating on the subject is under discussion. Unless and until this proves feasible, the Government agree with the Director that the remedy must be in the hands of buyers.

5. The results of the inshore fishing experiments at Madras described in paragraph 32 are not particularly encouraging. The Director has since recommended that they should be continued under private management at some small cost to the Government.

6. *Chank fisheries* (Paragraphs 32—43).—The season was by no means as favourable as the previous one and the profits were far less than those of the previous year. This continues however to be one of the most profitable of the heads from which the receipts of the department are derived.

The Government have already sanctioned the writing off of a sum of Rs. 969–8–7 being the irrecoverable arrears due on account of advances made to divers, and have now under consideration a proposal put forward by the Accountant-General for watching the recovery of such advances made from time to time. The Government agree that the most hopeful line of action to ameliorate the conditions of the divers will be to start socio-economic work among them and establish day and night schools, and await with interest the results of Mr. Govindan's efforts in this direction.

7. *Marine biological work.*—Only some nine months' work in this section is included in the year under report, the office of Marine Biologist having previously been vacant. The Government agree that a satisfactory start has been made and are glad to note the appreciation with which Mr. Whitehouse's work has been received by the institutions supplied by him with specimens. The work is, it is understood, at present much hampered by the lack of suitable buildings. The question of providing them will be taken up when a decision has been arrived at as to whether the work should continue at Tuticorin or should be transferred to some other marine centre.

The popularity of the Marine Aquarium, as evidenced by the receipts from visitors, showed a remarkable increase in the year, the receipts having advanced by nearly 150 per cent.

Owing to Mr. Hornell's absence on leave, no progress could be made in regard to the preparation of plans and estimates for the construction of the new Marine Aquarium and laboratories at Madras. Now that he has returned from leave, this question and his proposal to open a Fisheries College will be taken up for consideration.

8. *Inland fisheries.*—An interesting account of these activities is given by the Director in paragraphs 58–67 of his report. A number of incomplete schemes are included in this branch, some of which have had to be deferred owing to lack of funds.

9. The Government are glad to note the progress in co-operation among fishermen described in paragraph 21 of the report and the commencement of educational work managed by the department itself referred to in paragraphs 23 and 24. Temperance and socio-economic work progressed on sound lines.

10. The department as a whole was managed during the year (as shown in statement II) at a loss of Rs. 19,086 as against Rs. 42,026 profit in the previous year. The difference is almost

entirely accounted for by a fall in the receipts under chank fisheries, due to seasonal variations, and the department was still almost self-supporting.

11. The department continued to be satisfactorily administered and the year was one of progress in several directions, though many of the larger schemes of expansion have been unavoidably held up for lack of funds.

(True extract)

J. M. TURING,
Tempy. Addl. Secy. to Government.

To the Director of Fisheries.
,, Sir Frederick Nicholson, K.C.I.E. (paragraph 2 only) (with C.L.).
,, the Home Department.
,, all Collectors.
,, the Board of Revenue (all departments)
,, the Director of Statistics (with C.L.).
,, the Government of India, Commerce Department (with C.L.).
,, the Local and Municipal Department.
,, the Registrar of Co-operative Societies.
,, the Publicity Officer.
Editors' Table.

REMARKS ON CANNING.

CHAPTER I.

Origin of Canning.

This industry is necessarily one of modern development; necessarily because it involves containers absolutely air, water, and steam proof under all conditions, while bacteriological science can alone explain difficulties and failures other than mechanical and point out the remedy. The honour of the discovery is due to a Frenchman, M. Appert, who in 1809 announced his method of placing putrescible and fermentible articles in containers which, when hermetically sealed and heated to boiling point, indefinitely preserved the contents in good condition. An Englishman about the same time took out a patent for the use of tin plate containers of such articles, but the discovery is due to M. Appert who for, it is said, some fifty years (note the period) had practically dealt with and studied the preservation of articles of food.

2. The methods of M. Appert, though they would now be deemed slow and primitive, were identical in principle with those in use at this day, the results have been unsurpassed in durability, and in certain cases unequalled. But, chiefly owing to American ingenuity and necessity, the art of canning has enormously developed both in rapidity, neatness of execution, immensity of output, and a cheapness and general excellence of goods which could not have been dreamed of in 1809. In America the annual output of canned goods is numbered by the thousand million cans (over 3,000 millions in 1914, valued at £120,000,000 sterling) of fruit, vegetables, meats, and fish; no other country approaches it in the quantity and variety of its canned goods, though supreme excellence in certain lines, e.g., of fish, especially of sardines, is probably found in French factories.

The simple discovery that goods packed in hermetically sealed containers and then sterilised by heat, could be kept in sound and good condition for years together, has developed the present enormous industry.

3. The original need for canning and its vast development are due to the desires and demands of rich and civilised communities

for the varied products of their several localities, coupled with the possibility of supplying those demands by the advance of science applied to industry and by facilities for cheap transport. The fish of the coasts can be brought thousands of miles into the interior; the fruits and vegetables of one locality can be exchanged for those of others, or those of favoured regions, such as California, can be sent to the most distant parts of the world; surplus stocks of edibles grown or obtained in abundance during the summer can be stored in immense variety and attractive condition for the support and solace of winter months. Until canning (and later on mechanical refrigeration) was discovered, foods of a perishable nature were either not grown except for local needs, or were thrown away, or were cured—fish for instance—by methods such as salting, hard drying, smoking, etc., which preserved them indeed but only as articles not always palatable or even digestible, and which lacked the variety, savour, and succulence of natural products. Hence canning speedily met with favour, especially when steam brought cheap and rapid transport to the aid of enterprise.

WHAT CANNING IS AND MEANS.

4. Simply, canning is a method by which perishable goods can be kept almost indefinitely in closed containers from decay and deterioration, and even rendered more attractive to the palate, more rapidly digestible, and safer to the health than the raw product. More fully and scientifically described it is a method by which all classes of putrescible or fermentible products such as meat, fish, milk, fruits, vegetables, are packed in containers, usually of tin plate or glass, hermetically sealed so as to prevent the access of bacteria, and then, whether previously sterilised or not, finally sterilised by the action of heat to a degree which destroys all bacteria within the container, so that if the container is absolutely air-tight, putrefaction or fermentation is no longer possible.

5. The rationale of canning will be understood by a perusal of the chapter on putrefaction in the hand-book of fish-curing issued as a Fisheries bulletin. Briefly and simply it is this: the air swarms with minute vegetable organisms called bacteria which, according to their character, are the active causes of putrefaction and fermentation, while certain classes cause disease. These putrefactive organisms are comparatively powerless against living bodies, but instantly attack non-living materials such as meat and

fish, causing decay and putrefaction, a wonderful and wholesome provision of what we call 'Nature' for the disintegration of lifeless organic matter. They are so excessively minute that thousands can pass through an orifice as small as the point of the finest needle, while their multiplication is so rapid, usually by fission, that a single bacterium may easily become a thousand within 6 hours. Especially is multiplication rapid when temperature, moisture, and the nidus (breeding place) are suitable. It so happens that bacteria flourish and breed best between, roughly, 70° F. and 100° F., and this range of temperature, or the bacterial optimum, is precisely that found in India and the tropics during the greater part of the year; on the humid coast the element of moisture is specially favourable. Consequently, as experience shows, putrefaction in the Indian sea coast climate is enormously rapid, so that fish, which is more readily susceptible of putrefaction than meat owing to the less solidity and consequently more ready penetrability of its tissues, rapidly taints. Hence the tissues of meat and fish, etc., especially in India, are, within a few hours, full of putrefactive bacteria.

6. Fortunately these minute vegetable organisms are more or less paralysed by temperatures slightly above 100° and below 60° F., while as a rule they are entirely destroyed by a temperature of or slightly higher than 170 or 180° F. which is the general 'pasteurising' or sterilising temperature. Hence organic matter such as fish is sterilised as soon as every portion of the tissues is raised to this or a somewhat higher temperature, or in other words, cooked. But since the air is laden with similar bacteria, the fish are again attacked by them as soon as the temperature of the tissues falls below the above point, that is soon after they are removed from the cooking stove. Hence while fully cooked fish remain untainted longer than when uncooked because the bacteria have been wholly destroyed, they gradually taint by the action of fresh swarms of bacteria. Consequently to keep fish continuously and permanently from taint they must, whether previously sterilised or not, be placed in containers and hermetically sealed up, so that no air with its accompanying bacteria can have access to the fish, and the container with its contents must *then* be submitted to a full sterilising temperature (usually—for fish, meat and vegetables—that of or above 212° F. or boiling point) until the whole of the contents, *to the very centre*, have attained that temperature.

This sterilising in the containers is called 'processing,' and when the containers have been really sealed hermetically and the sterilising temperature has been attained *throughout* the contents, such contents are no longer susceptible of taint and will, for all practical purposes, keep good indefinitely, though delicate goods, such as fruits, are occasionally found to deteriorate from other causes.

7. Such is the rationale of the art of canning, which, so far as this matter is concerned, may be summed up as the art of sterilising foods in such way and in such receptacles that all existing bacteria are destroyed and the access of further bacteria is prevented. It is not the air that causes taint but the air-borne bacteria.

8. In the following pages the art as applied to *fish canning* will mostly be considered, and not as applied to meat, fruits, vegetables, jams, cereal and other products ; it is a bulletin mainly for fishery products and producers, but may be found otherwise useful.

MARINE BIOLOGICAL LABORATORY
WOODS HOLE, MASS.
LIBRARY

CHAPTER II.

CONTAINERS.

9. It is clear then that the provision of containers which can be hermetically sealed is the sine quâ non of canning. The invention of the tin plate can was the starting point of the industry as distinguished from the discovery of canning; no other material lends itself so cheaply and conveniently as tin plate notwithstanding certain disadvantages arising from its metallic character; glass jars or bottles though largely and increasingly in use, and preferable both hygienically as free from acting and being acted upon by the contents, and commercially as displaying the contents attractively especially in the case of fruits, are rather more difficult to seal hermetically and are very liable to fracture both in the process of canning and in transport; they are also heavier and more expensive; stoneware jars or bottles are heavy and do not display the contents, while wood and paper (pasteboard) containers are useless for absolutely hermetical sealing as required for fish, being porous and liable to shrinkage, etc. The chief disadvantages of the tin container are—

(1) its liability to act and be acted upon by its contents, especially if they are shell fish or acid fruits;

(2) their liability to rust;

(3) the invisibility of their contents.

But the advantages of lightness, strength, ease of hermetical sealing, cheapness, suitability for packing and transport, render the tin can the favourite class of container, and, as an abbreviation of the original word 'canister,' it has now given its name (cans and canning) to all classes of containers even when of glass. The containers generally dealt with in this bulletin are cans of tin plate being those most in use for fish canning.

10. The cans mostly used are—

(*a*) the ordinary rectangular tins of various sizes as used for sardines;

(*b*) oval tins;

(*c*) cylindrical, which may be flats of diameter comparatively wide as compared with height such as butter tins, or talls which are cylindrical cans of heights equal to or greater than the diameter, such as those used for American salmon, soups, jams, vegetables, etc.

These again may be differentiated by the mode of manufacture, viz.—

(*d*) soldered cans; and

(*e*) solderless or 'sanitary' cans made either wholly or partially without solder.

Or again they differ according to the method of opening, such as

(*f*) keyless,

(*g*) key-openers,

(*h*) tear or strip-off cans,

(*i*) full opening or capped cans,

(*j*) lever tops (though these are not capable of full hermetical sealing unless soldered round the cap),

(*k*) screw top, Phœnix, etc., cans, which however are glass jars or bottles only.

Finally they may be either plain inside or lacquered (so-called 'enamelled') to prevent chemical action.

11. As will be shown below, much depends upon the selection of proper shapes and sizes of cans; profits depend largely on this matter since with equal contents there may be great waste of plate, solder, labour, time, and fuel (in processing) by a wrong selection or by using improperly designed cans. Of course, profit also depends on the capacity of the cans, since cans similarly designated (e.g., 'quarters'; see below) may hold anything from 4 to 7 oz. nett of fish; this is a matter for the public.

12. In the United States of America certain standards are generally recognised, which, as regards the usual contents, are somewhat conventional. They either bear numbers which refer to conventional standards or are called 1 lb., 2 lb., 1 gallon, etc., probably relating to their contents in water, since the contents of fish, etc., vary considerably from the nominal capacities. For those who wish to order cans from the manufacturers it is necessary to consult the standard tables, an extract from which is here given, but slight differences are observable in different text books or trade lists.

Cylindrical; No.	Diameter; inches.	Height; inches.
1	2¾	4
2	3 7/16	4 9/16
3	4 3/16	4 ⅞
10	6¼	7

Here in India there are no recognized standards but the cans vary according to the pleasure of the manufacturer.

13. (*a*) In the case of *sardines* the French nomenclature is adopted which is nominally based on the kilogram (2·2 lb.), ordinary rectangular sardine tins being called 'quarters,' double sized tins 'halves,' and so on. But the quarter tin varies very largely in dimensions and capacity : some are 4½″ × 3″ × 1″ or 13½ cubic inches in capacity ; the ordinary 'quarters' as made in the Government Cannery are full 4¼″ × 3″ × 1″ or 12¾ cubic inches in capacity, weighing 9 to 10 oz. according to the thickness of plate but always containing full 7 oz. of fish ; the solderless cans are of similar size and capacity. 'Halves' may be only 4¾″ × 4″ × 1¼″ over all, outside measurements, or considerably below 24 cubic inches capacity when the covers are fixed, and weigh 13 oz. packed with about 10 oz. fish ; but American halves are stated to be 4½″ × 3½″ × 2″ or 31½ cubic inches capacity. These are not made in the Government Cannery but their place is supplied by simply increasing the depth of the 'quarter' can which then holds above 12 oz. of fish ; this is very economical in tin plate and solder ; or flat cylindrical cans (see below) may be used measuring 4¾″ × 1½″ over all, weighing 1 lb. packed and containing full 12 oz. and up to 13 oz. of fish. A rectangular can measuring 6¼″ × 4¼″ × 1½″ was provided for 'half' tins, but is not in use being extravagant in tin plate and solder as compared with contents. As is shown by the above figures the Government Cannery tins give full measure for the price charged.

14. (*b*) *Oval tins* are largely in use in Great Britain for herrings, pilchards, etc., and a common size is 7″ × 3¾″ × 1½″ outside measurements ; a smaller tin, as made by the solderless plant at the Government Cannery, is 6″ × 3¼″ × 1¼″ over all. A British small tin for herrings in sauces, such as tomato, measures approximately 5″ × 3½″ × 1½″ outside over all.

15. (*c*) *Cylindrical flats* may be of any desirable depth ; it is usual in a small factory to keep the same diameter and to vary the capacity by increasing the depth. For instance, in the Government Cannery the dies used give a cylinder of 4¾″ diameter (similar to a butter tin) with a depth of 1½″ : these are called (in the cannery) 12 oz. cans, since they hold full 12 oz. fish (mackerel ; rather more of sardines which pack closer), and weigh gross just 1 lb. or over. By simply adding to the depth, a can of the same diameter will

hold 24, 36 and even 48 oz. Of course cans may be made of any size by varying the dies.

16. *Talls.*—These are the usual tall cylindrical cans of comparatively narrow diameter so well known especially in American goods. The United States of America standard sizes and capacities and the numbers by which they are known are given in the table in paragraph 12 supra. An ordinary British or American 1 lb. jam tin might be 3½″ in height and 3″ in diameter or 3¼″ × 3⅛″ outside and over all; the cubical contents would be above 24½ to 25 cubic inches of water. These are not much used for fish except for salmon, and are not at present made in the Government Fish Cannery. They are very convenient for the manufacturer, their shape permitting great ease in forming the bodies, usually with lock side seams, in seaming on the tops and bottoms, and in permitting outside soldering and handling; where, as in packing salmon, the fish can be readily cut by machines into suitable chunks and automatically dropped into the cans, or where articles like peas, jams, etc., can be poured into the cans, this form is eminently suitable and economical. But they are useless for packing sardines, etc., which must be dealt with by hand. In addition to these cans there are the small tins, practically all cylindrical, used for holding pastes and various goods. For meat and fish pastes these are mostly 'talls' that is of height greater than the diameter, and are known conventionally as 3 oz., 4 oz., 6 oz., 8 oz., etc., tins, though not necessarily holding that weight of paste. Other goods are put in 'flats' where the diameter is greater than the height; e.g., boot polish, unguents, etc. The Government Cannery mostly uses 4 oz. capped tins of a size approximately 2″ in height and of similar diameter, or 'strip off' slightly taller and of less diameter, e.g., 2⅜″ × 1⅞″. But 6 oz. tins are convenient for the cheaper lines of fish pastes, fish meal, etc.

17. All the above cans may be made either—

(1) entirely as soldered cans, or

(2) entirely without solder, or

(3) by a combination of methods.

This will be dealt with below *s.v.*—'Can-making.' The Government Cannery makes by both the first two methods; the third has yet to be introduced.

18. Tins are also differentiated by the mode of opening or closing. The ordinary sardine tin is either 'keyless' which is

opened with a tin opener, or 'key opening' and is then provided with a wire 'key,' which rolls up the whole cover leaving the contents fully exposed. This class of tin is greatly preferable to the keyless since the top is necessarily obvious. so that the contents, e.g., sardines, are properly exposed on opening the cans, the consumer opens the tin readily without cutting his fingers or leaving a jagged edge, the fish are not torn by the tin opener and are therefore better in appearance, and the clean tin dish is more convenient for subsequent domestic use than the jagged one left by the tin opener. But they are necessarily slightly dearer. The Government Cannery does not at present make 'key openers' though the solderless plant is adapted for them.

The oval tins are also made as key-openers, but cylindrical are mostly keyless except the small paste tins known as 'strip off'; these are opened with a key which tears off a narrow strip at the top of the can, the strip following a groove in the tin plate; this leaves the contents visible and untouched.

19. The ordinary cylindrical keyless can is made either with the full opening or capped. The first named is a cylinder fully open at the top and closed when packed usually by a cylindrical top fitting inside the tin and soldered, or with a flanged top seamed to the body with a wash of solder externally. These are convenient for filling since the full width of the can is available. Capped tins are those which are sent out from the can-making factory with the top in place but which have an orifice of varying size, usually about ⅔ of the full diameter, through which the contents are packed; the orifice is then closed by a cap of tin plate which fits neatly into a groove provided on the top and is then readily soldered hermetically. This is convenient to the canner since the caps are easily and readily sealed, but are not so convenient to fill or empty, especially when the contents are paste. Lever-top tins are those which, like capped tins, have a central tubular orifice into which a dished cover is inserted and forced closely down; these however cannot be closed hermetically unless externally soldered in which case these tins lose their special value, viz., that they can be opened with a lever, such as a stout coin. Hence they cannot be used for putrescible goods, though suitable for goods like jams which are poured boiling hot into the cans, when the groove which surrounds the orifice into which the cover is inserted, may be filled with melted paraffin wax, dammar,

etc., and thus sealed almost or quite hermetically. Screw tops are, except for glass jars, unsuitable or unnecessary for cans that have to be sealed hermetically and subsequently processed.

20. *Glass jars.*—This elegant method of canning is practically, if not entirely, unknown in India, but is common elsewhere, and, until the war, was annually growing in favour. The advantages are—

(1) hygienic, since glass is not acted upon either by the constituents of animal tissues especially those of shell fish, or by the acids of fruits ; hence there is no danger of forming poisonous metallic compounds ; moreover the condition of the goods can be ascertained by inspection and bad goods (e.g., mushy fruits) rejected ;

(2) aesthetic, since not only can glass jars be made of pleasing form and appearance, but the goods, especially fruits, clear marmalades or jellies, whole fish roes and milts, etc., can be packed in a very attractive manner which of itself induces custom ;

(3) economic, since the glass jars can be used over and over again, or can be used for other domestic purposes ; moreover these jars are adapted for household canning since no soldering is required, and no plant except that found in most kitchens.

The disadvantages are their comparatively great weight, danger of breakage especially during manufacture if exposed suddenly to heat or cold air, and during transport, cost as compared with tins, and greater susceptibility to air leakage.

In the case of glass jars hermetical sealing is obtained wholly by atmospheric pressure ; the jars are filled with the product to be canned, lightly closed with a special cap and heated to the desired degree so that the air is expelled and steam produced ; on the cessation of boiling the steam condenses leaving a vacuum, so that the cap is forced down on the mouth of the jar by atmospheric pressure. The special caps are of several different forms, but always contain a washer of rubber or composition which fits accurately on the mouth of the jar which is made flat for the purpose. This washer closes the mouth air-tight and is kept in position by the cap which is either screwed down or clamped by a crimping machine under a shoulder in the neck of the jar. In a fish-canning factory in the United States of America, jars are placed in a vacuumising receiver, the air is thoroughly exhausted, and then let suddenly in so that the cap and washer are driven

tightly on the mouth of the jar, when the cap is at once screwed home.

21. It is obvious that while wide-mouthed jars can be used with great advantage in packing and removing the contents, there is greater risk of failure of vacuum or access of air than when the mouth is comparatively narrow. Still, very wide-mouthed jars, tumblers, bowls, etc., are in general use. These jars, under various patents, are excellently adapted for domestic use, since they can be used indefinitely often, while the work of fruit canning in such jars is simple to a degree; in petty domestic manufacture the personal care of an intelligent housewife prevents appreciable breakage or loss of contents. These glass containers have not been used in the Government Cannery not because of the difficulties in their use but because such jars have not been obtainable; even in pre-war days they were comparatively expensive, and from 1914 British jars have been wholly unattainable at any price. Indian-made screw top jars have been offered but *without* their screw tops and at prices for the empty jars almost as high as would have to be charged for the capped and filled jars when issued from the cannery. Glazed stoneware jars can be similarly used if provided with proper caps, but are even heavier than glass and hardly, if at all, procurable in India, partly owing to the cost of freight, while Indian-made goods of this class if procurable at all—which is seldom—are poor in quality and absurdly high priced.

CHAPTER III.

CAN-MAKING.

22. In the United States of America where the demand for cans is enormous and continuous, freight and packing cheap, and cans more or less standardised, it is common to find large factories devoted entirely to the manufacture of cans and supply to canners. With the most perfect and rapid machinery and with the attention paid to economy and perfection, it is probably better for canners to buy from such manufacturers than to make them in the cannery where, as being a mere side-line of work, the cans turned out are apt to be less perfect than those of the can-making factories in which 2 per 1,000 of imperfect (leaky) cans is considered a maximum. In buying ready-made cans the canner is fairly certain of perfect cans, and the cost of such cans and their freight is more than recouped by the comparative absence of losses from rusty tin plate, spoilt empties, leaks after packing, and by the ability of the canner to devote his sole attention to canning; moreover many factories are too small for a can-making plant.

23. Here in India it is almost necessary for a fish-canning factory to make its own cans from tin plate, and the Government Cannery is no exception. There are very few can-making factories; those which exist are mostly either for small tins as used for medicines, unguents, etc., or large (kerosine) tins made by firms importing kerosine; all are very far apart and distant from canning factories; there is no factory at all for making the special sardine tins. For the small 4 oz. cylindrical paste tin, it has been found advisable hitherto to obtain them ready made from England, owing to the slow and imperfect work of Indian solderers, but it should be possible now to make such and similar cans with improved and not costly plant as described below. It is also possible to obtain tin plate already decorated and printed, thus minimising the cost and labour of varnishing, labelling, etc., while obtaining a neat and attractive appearance. These decorated plates are then cut to size, formed up, and soldered into the usual cans.

24. *Soldered cans.*—The following paragraphs chiefly relate to the manufacture of cans as practised in the Government Cannery.

25. *Material: Tin plate.*—At present this is only obtainable from Great Britain and America, but it is believed that it will shortly be available from Messrs. Tata's Steel Works. Tin plate consists

of very thin sheets of steel coated with tin, and is usually packed in boxes containing 112 sheets ; these boxes weigh very differently according to the area and thickness of the plates, e.g., from 70 to 160 lb. The selection of plate is a most important matter in every way ; if cans solid drawn from the flat are made, the plate must be of specially ductile character or the bodies cannot be struck without great loss from fractured or torn metal. If the areas of the plates are not carefully adapted to the intended size of the cans, so as to get the maximum number of bodies or tops and bottoms with the minimum of waste strips, the cans will be costly and the metal wasted. If the gauge is too thick there will be unnecessary cost since the plates are charged for by weight, while the cans will be uselessly heavy and hard to cut open ; if the gauge is too thin the cans will be weak and, especially if processed under pressure, may 'spring' and bulge with a permanent 'set' owing to expansion. so that the tops or bottoms will have the appearance of 'swells' and be rejected by dealers and consumers though in reality perfectly good ; such cans, in which the top or bottom can be pressed in and out like a loose drum head, are technically called 'springs' to distinguish them from 'blown tins' or 'swells' which are caused by decomposition, and of which the tops and bottoms are *both* convex and cannot at all be pressed in. See paragraphs 136—139 below.

Rusty plate must of course be avoided both by reason of bad appearance and of effect upon the contents and sealing of cans. Solder does not adhere to rusty edges ; this is a fruitful source of leaks especially in hot and humid climates and when cans are processed under pressure (see below *s.v.* 'Processing ').

26. The quantity of tin per square inch of plate is very important; cheap plate is apt to be defective both in the quality of the metal and the quantity of tin used. Since the tin protects the iron from rust and from corrosion by fruit and other acids, no plate should be used which is not up to high standard. For it is principally the action of acids and other elements on the iron of the tin plate that causes improper flavours and not the action on the tin, which is usually unimportant in fact except as regards appearance (e.g., the blackening of prawns), though very occasionally found in the goods. Fortunately iron salts are innocuous.

27. *Solder.*—This essential item is often insufficiently attended to, though perhaps, in India, the most costly single item in a can. In a full-sized quarter tin there are 29 inches of soldered seam

uniting the top and bottom to the body which has also a vertical seam or thick line of solder joining the two lapped ends of the strip which forms the body. The 'half' tin, as originally obtained for the Government Cannery, was abandoned largely for this reason; being 6″ × 4″ there are actually 40 inches (more than a yard) of soldered seams in top and bottom, plus the body seam; this length of seam demands much solder even with the greatest care, much more with inexperienced men or men careless of waste.

28. The solder used in India is the ordinary stick solder made of lead and tin in varying proportions, but usually one part of tin to one and a half parts of lead, since a soft, easily flowing, readily adherent solder is needed. Though lead is far cheaper than tin it is not always economical to raise the proportion of lead since such solder is less adherent. In America 'drops' and wire segments of solder are generally used, and since experience has shown the due proportion of solder to a given length of seam, only this much solder is issued; hence great economy. The most economical use of solder is obtained in 'capped' tins by using 'solder-hemmed' caps in which just the requisite amount of solder is run on to the edge of the caps by the can manufacturer; these 'hemmed' caps are then placed in position and sealed in the usual way. This not only effects economy in solder but saves time and labour and, what is equally important, protects the edge of the cap from rusting.

29. It is sometimes economical for the canner to make his own solder, but great precautions are necessary to prevent waste by oxidation of the metals, etc., and to ensure a complete and homogeneous mixture, since the two metals, being of different specific gravities, tend to separate in the melting pot.

30. *Can-making plant.*—The plant actually necessary for the small can-making installation is cheap and simple, but in large factories there is usually expensive plant, power driven and largely automatic; those will not be here described since in India it is usually cheaper to increase output by multiplying small plant worked by hand or small power; any number of cans can be turned out by increasing the number of solderers.

31. In the Beypore Cannery the following plant—all manual—is used, viz.:—

(1) A guillotine plate cutter for squaring the sheets and cutting them into the greatest possible number of the strips which form the bodies;

(2) a notcher for notching the ends of the strips;

(3) a machine for rolling and beading (or fluting) the strips;

(4) a body-former for bending the strip into the rectangular shape of a sardine can body;

(5) a machine for holding the two ends of the strip together when soldering so as to form the body;

(6) a swan-neck press with separate dies for striking tops and bottoms either for rectangular or cylindrical cans;

(7) a set of solderers' turn-tables, worked by the foot, with 'ratières' or steel boxes for holding sardine cans during the process of soldering tops and bottoms to the body, and clamps for holding cylindrical cans; also the necessary fire pots and 'coppers' or soldering tools. In the Beypore Cannery the soldering irons are heated by charcoal in the fire pot, but in more advanced factories outside of India, the coppers are heated in oil burning stoves (of the 'Primus' character), or, still better, are self heating by means of a jet of mixed gas and air (e.g., petrol air gas) delivered under pressure from a generator or reservoir to the copper itself where its combustion keeps the copper always at the proper temperature; this makes for great economy in time and labour.

Items Nos. (1) and (6)—guillotine and press—are the only items of any considerable cost, and can readily be obtained at very moderate prices; the press should be fitted with various pairs of dies for cans of different shapes and sizes. Lists and description of plant can be obtained from the Government Cannery at Beypore.

32. The sequence of operations for sardine tins is as follows: for bodies the proper sized plate is placed in the guillotine and squared; it is then cut to the fixed width automatically by the action of a pedal; the strips, which fall into a box, are then notched at the two ends and passed through the beading rollers which turn them into beaded or fluted strips. The beaded strip is then bent round a rectangular block, the two ends brought together with a slight overlap, and clamped under a plate, through a slot in which a boy solders the two ends by an outside line of solder. The rectangle is then slightly swaged on a block to admit the stamped plate with a curled rim, which forms the bottom; this is then placed in a ratière or steel box which squeezes the body strip and bottom plate closely together, and the combination is then

soldered. This forms the dish or box in which the sardines are packed, and is closed by a lid precisely similar to the bottom plate. The object of the ratière is not only to hold the body while being soldered but to squeeze body and bottom (or top in packing) close together so as to form a very narrow channel for the solder; this prevents waste of solder or the solder from dropping into the body. The tops and bottoms are struck at one blow out of the flat in the swan-neck press, which at the same time cuts the proper sized piece, stamps it with its beading or fluting, and curls about ⅛ inch all round into a rim at right angles to the plate; this curled rim fits inside the body.

For cylindrical tins the method is the same, mutatis mutandis, but no ratière is used, the cylindrical dish being simply centered on a turn-table for the application of the solder.

33. It may be well to tabulate certain figures showing waste or economy in making soldered cans.

No.	Name of can.	Size of can.	Approximate contents in fish.	Cubic capacity.	Tin plate required.	Length of solder seams.	Remarks.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			OZ.	C. INS.	SQ. INS.	INS.	
1	Quarter (Government Cannery).	$4\frac{1}{4}'' \times 3'' \times 1''$	7	11	44	30	For item 1, columns (2), (3), and (4) refer to both soldered and solderless quarters. The tin plate required includes rims or flanges, but not waste strips.
2	Quarter (elsewhere).	$4'' \times 3'' \times \frac{7}{8}''$	$5\frac{3}{4}$	9	40	29	
3	Do.	$4'' \times 3'' \times \frac{5}{8}''$	4	6	37	$28\frac{3}{4}$	
4	Quarter (French)	$4\frac{1}{2}'' \times 3'' \times 1''$	$7\frac{1}{2}$	12	46	31	
5	Half (Government Cannery).	$6'' \times 4\frac{1}{4}'' \times 1\frac{1}{8}''$	$13\frac{1}{2}$	24	79	42	Item 5 not used.
6	Do.	$4\frac{1}{4}'' \times 3'' \times 2''$	13	22	58	31	Item 6 in regular use. Items 8, 9 and 10 are in regular use at the Government Cannery for mackerel, prawns, fish in slices.
7	Half (elsewhere)	$4\frac{1}{2}'' \times 3\frac{1}{2}'' \times 1''$	$9\frac{1}{2}$	16	52	33	Item 7 is a small half.
8	Cylindrical (Government Cannery).	$4\frac{3}{4}'' \times 1\frac{1}{2}''$	12-13	24	60	30	
9	Do.	$4\frac{3}{4}'' \times 3''$	24-26	50	82	31	
10	Do.	$4\frac{3}{4}'' \times 4\frac{1}{2}''$	36	76	103	33	

All figures are near approximations, small fractions being omitted; cans in different factories differ so considerably that absolute exactness is impossible. The French half is somewhat larger and holds more fish than item 7 in the table.

34. Column (3) represents over-all measurements and not inside. Column (4) represents actuals as many times tested, the cylindrical cans usually holding slightly more than the contents quoted. Column (5) gives the cubic capacity *inside* with the cover fixed and is not arrived at by multiplying the figures of column (3). Column (6) gives the area of the tin plate actually found in the cans: it is somewhat larger than the figure arrived at by multiplying the figures of column (3) since the tops and bottoms have curled rims of about ⅛ inch depth, which adds to their surface area. The waste involved in cutting tops and bottoms from a plate has not been included. The length in column (7) gives the length of the solder seams, and includes the side seam of the body as well as those uniting tops and bottoms to the body.

35. It is now possible to compare shapes and sizes with cost in tin plate and solder and with capacity and contents. For instance if a quarter be only ⅝ inch in depth instead of the full 1 inch, it will hold only 4 ounces of fish as against 7 in the full sized tin and yet demands considerably above three-quarters (37/44) of the tin plate and practically as much solder as the larger tin. The badly designed half, No. 5, holds 13½ ounces of fish as against 13 ounces in No. 6 which is an ordinary 'quarter' sized can but of double depth; yet No. 5 takes 78 square inches of tin and 42 inches of soldered seam against 62 and 31 for No. 6; No. 8 cylindrical compares still more favourably with No. 5. Numbers 8, 9, and 10 like No. 6, show the value of increasing the capacity by increasing the depth; No. 8, a 12-ounce cylindrical tin of 1⅜ inches inside depth and 24 inches cubical capacity, takes 60 square inches of tin plate and 30 inches of soldered seam, while No. 9 holds double, viz., 50 cubic inches, with an increase of only one-third of tin plate and 1/30 of solder seam. The reason of course is that while the tops and bottoms remain the same in area, the capacity is exactly doubled, etc., by simply increasing the width of the strip which forms the body.

36. Apart from the saving effected by a judicious selection of the sizes and shapes of cans, it is obviously to the interest of both canner and consumer to use tins as large as are found suitable to

the specific fish packed and to the market. For in using large tins, especially those doubled or trebled in capacity by merely adding depth to the body strip, the canner not only necessarily saves largely in tin plate and solder, as shown above, but also a great amount of labour in all the canning processes from packing to labelling and sale; it is obviously easier and quicker, and therefore cheaper, to solder, test, exhaust, process, clean, label, etc., 100 half tins such as No. 6 than 200 quarters such as No. 1, and there are fewer spoils. Owing to these considerable savings a half tin (No. 6) of sardines can be sold at a price less than 50 per cent above that of quarters; a cylindrical No. 8 can sells slightly above a quarter tin. Moreover, many fish may require the larger, e.g., No. 8, tins owing to their shape and size, whether whole fish, such as our small mackerel, or sections of large fish, or prawns which do not pack closely. The consumer is equally benefited if he requires, as in schools, clubs, hotels, etc., a considerable quantity of fish for a meal, since he gets the same quantity of fish far more cheaply; in one reported case, a hotel used thirty-six 'quarters' (No. 1 size) of sardines at one meal, costing Rs. 13-8-0 at 6 annas per tin, while 18 'halves' of No. 6 with the same quantity of fish would have cost Rs. 9-9-0 at As. 8-6 per tin. Hence the canner to be successful must carefully study the dimensions, shapes, capacity, and modes of increasing the capacity of his cans, using large cans when the market admits of it. In any case, since, in this Presidency, the fish is usually the cheapest single item in a can (compared with oil, tin plate, solder) it is well to use tins of good size with plenty of fish and thus please the consumer by giving good value.

Nevertheless it is very necessary to study and humour the special demands or fads of the market; it is almost useless to try and get goods into some markets, especially outside of India, which in, it may be, mere size or appearance, do not fit in with the custom of the market, even though the new goods give better value than the old ones. Markets and buyers may seem unreasonable but they must be humoured.

37. *Solderless cans.*—There are certain disadvantages attending soldered cans;

(1) they should be made shortly before use since, especially in a hot and humid climate, the edges rust so that the solder will not adhere securely; hence the risk of severe losses in leaks;

(2) solder is not always of good and even quality;

(3) solderers, especially in India, work very slowly so that there must be a large staff; this is not always procurable, and among a large staff there are sure to be careless or unskilful hands who may cause heavy losses;

(4) a careless solderer not only allows leaks but wastes solder; this single item, apart from leaks, may swallow up much of the profits on a batch;

(5) in processing by pressure steam a weak solder joint may easily give way in the kettle (see elsewhere) or on removal from it, and serious loss may then result;

(6) the joint which unites the two ends of the body strip is usually a lap joint, i.e., one end laps over the other about 1/8 of an inch and the two ends are united by a large quantity of solder, which, from pin holes, is often a source of weakness. In any case the joint is weak, costly, and ugly.

38. Consequently—and for other reasons—it has been sought to close cans hermetically wholly without or with a minimum amount of solder. In the Beypore cannery a line of machines has been set up which entirely dispenses with solder, viz., by 'drawing' (pressing) the dish or body of the can from the flat at a single blow, so that a flat piece of tin plate becomes a perfect body without seam of any sort. This dish is flanged by the same blow, and the narrow flange is then trimmed to a proper size in another machine. The second machine also strikes the covers, and a third machine affixes rubber composition rings (washers or gaskets) to the covers. When the bodies are duly packed with fish, they are brought to a fourth machine called a 'double seamer', the covers are laid on the bodies, and the machine then clamps the cover and body together in a seam by turning the edge or rim of the cover under the lower edge of the flange of the body—the rubber washer being between them—and then forcing the two flanges together in a hermetical joint. The result, if the double seamer is properly adjusted, is a perfectly sealed can without a particle of solder, with only the one seam, viz., that which unites the body and the cover, and consequently with less chances of leakage than in the soldered cans. The machines can be provided with different dies and chucks so that cans of various shapes (round, rectangular, oval) can be made and closed in them. The Beypore plant has a set for quarter tins and for medium ovals. Similar tins of small size and shallow, such as those used for boot polishes, medicines, samples,

etc., are usually struck in this way, as also the cheap penny tins of fish paste.

39. This system has the following advantages:—

(1) comparative absence of joints and seams;

(2) the freedom from contamination by the lead in the solder though, in properly soldered cans, this is negligible;

(3) comparative absence of leaks, provided the double seamer is properly adjusted, and the rubber washers are in good condition;

(4) great speed; one machine will close as many cans as a dozen solderers;

(5) the dished cover of the tin is forcibly pressed down in the double seamer on to the contents, so that air is practically excluded and exhausting is seldom necessary, at least for sardines, etc., which can be closely packed;

(6) as solder is not used, the cans and covers can be prepared at leisure and stored since the condition of the edges of body and cover does not affect the hermetical sealing;

(7) the nature of the joint between the body and lid is a mechanical lock, so that there is no risk of joints giving way in processing even at high pressure;

(8) the operation of double seaming being mechanical, it may be carried out by any one after slight teaching, so that there is no lengthy apprenticeship as for solderers.

40. The disadvantages are—

(1) that the machines are costly and require somewhat delicate adjustment, especially in the drawing press and double seamer, and do not work to perfection unless perfectly adjusted; hence a good mechanic or mechanical engineer is a necessity;

(2) that the composition rings are apt to deteriorate especially in India, unless protected from the air; hence leaks are possible by breakage of the rings or by their being squeezed out of place: it is found necessary at Beypore to heat the lids and rings immediately before double seaming;

(3) oil rapidly deteriorates rubber or composition containing rubber, and since sardines are preserved in oil and all fish are more or less oily and since the act of double seaming forces out some of the oil and over the rubber ring, the rubber must deteriorate within a comparatively short time, and thus cause damage to goods if kept long.

Disadvantages (2) and (3) can be obviated by using a solution instead of a rubber ring; this solution often contains no rubber,

but consists of oil, etc., dissolved in a volatile spirit; this when applied either by hand or by a 'lining' machine and dried provides a continuous and elastic washer unaffected by oil. In Beypore the rubber is now to be protected by a solution which will indirectly improve the sealing and the life of the joint.

The machines installed at Beypore can make and close under Indian conditions some 2,000 solderless cans per working day *provided* that fish are available early in the day and continuously; a second double seamer worked by one man would double the output as the other machines can be worked at various times and thus store up cans.

The power is given by a 5 I.H.P. engine.

41. *Semi-solderless cans* are cans which are partly seamed, partly soldered, the solder being less or more according as the seams are or are not provided with composition gaskets inside the seam. This class of can includes the United States of America 'sanitary' can, so called because it does away with the possibility of contaminating the contents by solder or by the fluxes of which some are poisonous. The sanitary can is mainly a cylindrical 'tall' can such as is used for salmon, preserved fruits, jams, soups, etc.; the cylinder is formed as usual from a strip of tin plate, but the junction is effected not by a line of solder as in a soldered sardine tin, but by a lock seam formed by folding or interlocking one edge with the other; the locked or folded seam is at the same time squeezed flat by a grooving arrangement so as to form an almost air-tight joint; if a composition washer or a solution has been interposed the joint is hermetical as described s.v. 'solderless' cans, but otherwise an external wash or floating of thin solder completes the sealing of the joint. The cylinder is provided with a flange at the top and bottom produced by the machine when forming the body; the bottom flat is then seamed on, with or without a sealing gasket, in the usual way by a double seamer. For many goods which do not taint or ferment a plain seam without a washer is sufficiently air-tight, but for goods requiring hermetical sealing the seam is either sealed with the usual interposed washer or by an external application of thin solder. The can which is thus a cylinder open at the top to its full width, is then packed with the goods, and the cover, which is a replica of the bottom, is sealed on to the flanged top in the same way as the bottom. This provides a can sealed by seaming, and rendered

absolutely air-tight either by the usual washer or by an external wash of thin solder which is generally applied automatically.

42. The locked side seam with an external wash of thin solder, may be introduced into the ordinary fish tins (rectangular or cylindrical) when the body is formed from the strip; this will give a much neater and stronger seam and save solder. An attempt was made at Beypore to introduce it, but the locally made tool was insufficient and none was then—during the war—obtainable from England.

43. For all cylindrical tall cans, i.e., those in which the height is equal to or greater than the diameter, this 'sanitary' or semi-solderless method is a great improvement, as the cylindrical shape lends itself to the method, and the can is both stronger, neater, and cheaper.

44. But to render any can fully 'sanitary' in the sense not only of dispensing with solder and acid or other fluxes and of more complete hermetical sealing and consequent diminution of spoilage, but of preventing any action of the contents on the metal, something more is needed, especially with certain classes of goods such as prawns and shell fish, marinated fish, fruits, jams, jellies, etc.; even ordinary fish, when not put in oil, are the better for protection from immediate contact with the tin plate. In all these cases certain constituents of the contents, e.g., the sulphur or phosphorus in prawns, the acetic acid (vinegar) in marinated fish, the acid in fruits and jams, act upon the metal of the containers; prawns rapidly blacken and though not perhaps poisonous are so unsightly as to be unsaleable or rejected by the consumer; acid jellies also blacken and dissolve the tin from the plate. So far nothing has been successful in *absolutely* preventing such action, but lacquered or so-called 'enamelled' tins are now largely used. Lacquered plate is now sold in which the lacquer is so completely united with the metallic surface that cans can be made from the flat plates without the lacquer cracking or peeling, but this lacquering is usually very thin, and is often entirely removed if the cans are boiled in even a weak solution of sodium carbonate for the purpose of removing grease. In other practice, as at Beypore, it is usual to apply the lacquer (usually an oil varnish with turps) to the interior of the formed can, either by painting or spraying; the can is then baked to harden the lacquer, and the process is generally repeated, forming 'double lacquered' tins. The baking is done

either in a special oven or in the (Beypore) 'solar oven,' * in which a temperature of over 300° F. can be obtained during the hot weather and always, on sunny days, above 250° F. It is well known that baking thoroughly hardens the lacquer, and that, within limits, the higher the temperature of baking the better the lacquer will stand subsequent heat, as in processing at 240° F., without alteration. This double lacquering is a great improvement, and when vegetable parchment paper is added as a protection, even prawns keep very fairly for years, being frequently as bright as when packed. But this lacquering is not quite sufficient *per se* and other linings are needed and in some cases adopted; a cheap 'enamel', unaffected by steam at 250° F., is now hoped for at Beypore, and this will prevent all further difficulty; cans will then, be wholly 'sanitary'.

* The solar oven is a shallow teak box, the top of which is a double sash of glass; the box is blackened inside with a dead black and insulated by insertion in a larger box with saw dust or rice-husk insulation. The whole is then so mounted that it can be kept facing the sun at such angle that the rays will always be perpendicular to the glass sash. Since direct rays will penetrate glass readily but radiated rays with difficulty, the heat is trapped within the box and produces a temperature usually double or more than double the external sun temperature as measured by a thermometer placed in the open sun. With wings of tin plate set at an angle with the glass surface, the temperature has been raised to 325° F. in March. Since soft solder softens at not much above 300° F. this heat is more than sufficient. Baking in this oven costs practically nothing.

CHAPTER IV.

Canning.

45. The plant and methods in can-making have been described above; the following paragraphs relate to the *canning* of various products. The plant and processes to be discussed below will deal mainly with *fish-canning*, but other items will be mentioned as opportunity offers.

46. *Plant.*—This varies immensely according to the character of the factory, whether domestic or commercial, whether simple or up to date, whether for one or two products or for many, whether cooking is under pressure at high temperatures (up to 250° F.) or only in open pans at 212° F., whether for fish and meat or for fruits, vegetables, or preserves of the same. The highest class of goods can be made on the smallest scale and with very ordinary plant; indeed small scale domestic products when made by experts and with high class material, are usually superior to commercial products which are made in bulk sometimes with more attention to quantity than quality and with various sophistications, diluents, preservatives, etc., which though innocuous and even wholesome are not always strictly according either to the labels or to the requirements of the 'pure food laws.' Hence an honest and *instructed* man with small capital and plant and buying ready made tins or other containers, can make excellent goods and a decent livelihood in his own house; if such house is at the sea side he can arrange for the freshest fish at cheap rates; if in a country village he can grow and buy his fruit and preserve it for use or sale in the most perfect way. It is possible (and plant can be obtained as per advice of the Board of Agriculture in London or of the writer), to buy for a few pounds a small plant including soldering apparatus which will make quite a quantity of preserved food. These small plants will be the subject of a special paper; the present bulletin deals mainly with factory work large or small.

Buildings.

47. The first essential is good, airy, clean accommodation in buildings which admit plenty of air and light, well provided with clean water laid on, and with floors and walls and drains which can be freely sluiced and flushed with water and antiseptics. It is

not advisable to use upstair buildings; sheds on a low basement, with concrete and cement or tiled floors and good walls plastered with cement or lime mortar are recommended; ample windows with screens are necessary; or the walls may be dwarf walls provided with palisading of wooden uprights or of expanded metal, etc., the roof being carried on masonry pillars. Screens (of tatties, etc.) are necessary to keep out dust, glare, rain, etc., and if flies are troublesome gauze screens may be needed; anyhow curtains of fishing net are advisable to doors and windows to keep out crows which foul and steal the goods. Indeed cheap and excellent sheds for much of the work may consist of a good floor with very low dwarf walls, pillars, a roof, and heavy coir net hangings to keep out crows; good bamboo tatties are however necessary to shut out dust and rain and to close the sheds at night. The curing sheds at Tanur are of this nature. The sheds should be so arranged that, as far as possible, the several processes can be conducted in orderly sequence, without zigzagging from point to point and process to process. The rooms or sheds required are—

(1) a gutting, washing, and brining shed; this should be separate from the packing, closing, and processing sheds;

(2) a drying ground with scaffolds or 'flakes,' and possibly a drying room;

(3) a shed for frying and packing the fish into containers and for the miscellaneous operations required at this stage;

(4) a shed for soldering or otherwise closing the containers and for the various processes of testing, exhausting, processing, etc., the closed cans; the boiler, if any, is usually placed in a shed alongside this room, while the engine for driving the stamping, closing, etc., machines, if any, may also be placed within the processing room. Of course in large factories the can-making plant will be in a separate building with perhaps its own boiler and engine, but the processing room requires an engine or shafting, etc., driven from an engine, if solderless cans are in use;

(5) a testing or observation room in which the finished goods are kept under observation (for the detection of spoiled cans);

(6) storage room for keeping the cans which have passed the observation room;

(7) an issue room into which the goods are passed by the storekeeper as required for market, where they are labelled and packed;

(8) a store room for the several condiments, etc., required in packing and specially for salt;

(9) a room for storing tin plate, solder, empty cans, lids and other can-making stores;

(10) a miscellaneous store-room;

(11) fuel shed for coal, wood, and charcoal;

(12) a small boiling pan, etc., for dealing with guts and debris from fish for manurial purposes, with store shed;

(13) office quarters;

A laboratory for testing spoils, examining the oils supplied, etc., is of course desirable, but at present is hardly possible under Indian conditions.

48. (1) *The gutting, etc., shed.*—All fish require gutting and brining the moment they arrive at the yard, especially in India where no such operations are conducted on the boats. This is necessarily an uncleanly business and the shed must be not only open and airy but of such impervious material that it can be sluiced continually with clean water and disinfectant; the water should be laid on, both for this purpose and for washing the fish. The gutting tables may be made of stout, hard, seasoned wood, since such wood does not admit of much soakage and can readily be scraped and scrubbed; those at the Government Cannery have been in use for some years and are perfectly sweet and clean. It is well to have them of wood, since in gutting fish such as mackerel they must be decapitated by the knife and not by scissors; stone or metal would destroy the knife edges. Metal pails are necessary for receiving heads and guts and removal to the manure shed or pits. The washing vats or tubs may be two or more masonry cisterns with water laid on, one being in use while the other is being emptied and refilled with clean water. Good drains, preferably open and of semi-circular section to avoid accumulation of foul matter, are essential to carry off foul water from floor and washing tubs. The brining tubs may be of good wood (half barrels), with spigot and faucet. The shed may be a few yards from the other sheds.

49. (2) *Drying ground.*—After gutting and brining sardines are placed upon grilles, and other fish on network trays made of uniform size, in the brining room and thence removed for drying, which, in India, is usually in the open air and sun. It is convenient to hang the grilles from a scaffold since the warm air

rapidly and thoroughly dries the fish, but they may also be placed on 'flakes.' In temperate and uncertain climates a drying room is advisable, with, if possible, a fan driving or drawing a current of heated air over the grilles; this is expensive but effectual. Sometimes the room is simply heated, e.g., with steam pipes or stoves, and free ventilation provided by ridge ventilators or by windows. In the United States of America, Canada, etc., a drier such as the Whitman drier, described in paragraph 80 of the Fisheries Bulletin (1st edition) on the "Cure and Preservation of Fish," is in favour.

50. (3) *The frying and packing shed.*—From the drying ground or room the fish are taken to the packing room. Sardines are here fried in oil or otherwise pre-cooked in stoves made for the purpose; mackerel and slices of other fish are also sometimes fried. The fried or merely dried fish are then packed, for which tables, preferably covered with zinc sheets, slate tops, etc., must be provided. Tables and shelves are also required for the empty cans, oils, and other condiments used in packing. The shed must be airy and light in order to minimise the effect of fumes from the hot frying oil and to enable the packers to work accurately. Since work is often carried on after dusk, powerful hanging lamps are desirable.

51. (4) *The closing and processing room.*—The packed cans are then taken to the closing and processing shed. Here there must be a series of tables for the solderers, one or two troughs heated by open fire or by steam for testing, exhausting, and for processing if the open tank processing is adopted, and one or two steam pressure kettles if steam is used. This room must also be airy and light and provided with powerful lamps, since both soldering and testing are delicate processes and night work is frequent in India. If solderless cans are used, the machines for at least the closing of the cans (double seamers) must be placed in this room; at the Government Cannery the whole line of solderless can-making machines is so placed. Since the solderers for closing the packed tins are accommodated in this room, it is here also that the machines for making the soldered cans are placed because the same solderers and their tools are employed in making the empty bodies. In brief this room is used both for making the cans whether soldered or solderless and for closing, etc., the packed tins. In a large factory where millions of cans have to be made, it is advisable to have a separate can-making shed, merely placing the double seamers in

the closing shed, but in small Indian canneries the Beypore plan may be adopted.

52. (5) *Observation room.*—To prevent leaky cans which may not have been detected in testing or which have subsequently developed leaks, from getting into store or market, a room with large racks and tables is provided in which all cans are kept for 10 days or so before being passed into the store room; this saves great trouble in the store room by the presence in and removal of bad tins from the piles of good ones. The remaining buildings need no special description.

53. It need hardly be said that, if possible, the premises, both land and buildings, should be of sufficient area to prevent crowding and to permit of free ventilation; also that everything should be so arranged and cleared as to be perfectly sanitary, the open ground being kept clear of all accumulations of dust and rubbish. The guts and offal generally should be removed to a distance and then boiled down for oil and fish manure.

FITTINGS.

54. (1) *Water-supply.*—Arrangements for plenty of clean water, laid on to every room for sluicing the rooms daily; water is specially needed in the gutting and processing rooms. In the Beypore Cannery, as at Tanur, perfectly fresh water is obtained throughout the year by driving 'tube wells' into the sand; even though the sea or tidal river or back water be close by, fresh water is always obtainable. These 'tube wells' are simply steel tubes having a 'filter point' at the lower end; this filter point is a perforated tube about 3′ 6″ in length ending in a sharp point; a pit is dug in the sand, if possible in the hot season when the water-bearing stratum is at its lowest, till water appears, perhaps at 8 or 10 feet; the filter point is then driven down as deep as possible into the water bearing stratum, a length of steel pipe is screwed air-tight on the filter point which, if possible, is then driven further down so as to secure plenty of water at all seasons, and the pit is then filled up, any further lengths of tubes being added; at ground level a pump, usually semi-rotary, is screwed air-tight, and after a short time water flows freely. This water is perfectly clear and pure being drawn not from an open well but from a stratum 10 or 12 feet below the surface which stratum is covered by the natural filter bed of superincumbent sand. From

such tube wells the water should be forced to a large masonry tank fixed at such a height—not higher so as to save labour in pumping—as will, allowing for friction in the pipes, supply every part of the cannery with tap water. Plenty of pure water and its continuous use is a necessity in a cannery.

55. (2) *A provision of solid hard-wood tables, etc.*—Those in the gutting room slope very slightly either to the edges or to the centre where a small channel carries the washing water and offal into buckets or drains. Since the knife is often used upon fish the tables are wooden rather than stone and zinc covered. The tables in the packing room may usefully be covered with zinc or may have slate or tiled tops since spilt oil and fragments of fish soil the tops. The solderers' tables are long narrow tables on which the cans are placed for closing, the men sitting behind them with their turn-tables. There should also be a variety of small tables or racks for holding the wire baskets full of cans at the testing and exhausting vats, etc. Wooden stools for the staff are also necessary.

In the observation room there should be one or two large tables, and racks to hold at least one week's outturn.

The store room should be entirely surrounded by wooden racks with others in the middle space, and should accommodate at least three months' output; these should be arranged and labelled according to the contents of the cans, so as to avoid confusion. If by reason of heavy output the cans are piled on the floor arrangements should be such that defective (leaky) tins may at once be detected and removed lest the tainted fluids from such cans cause unpleasantness and soil other cans.

The issue room should have proper racks for storing the labelled tins upon issue from store; the labels themselves should be neatly stored in packages in a convenient set of labelled drawers, so as to prevent confusion and loss. The packing of tins into cases for despatch is usually carried on in this room or its verandahs.

The fittings of the office need no description, while those of the laboratory depend on the work to be done.

Machines and Tools.

56. In the gutting shed the chief tools required are *sharp* knives and scissors, all of good steel, for which it is well to have a small

grinding stone or emery wheel and good carborundum hones. For cutting slices of large fish a guillotine slicer capable of being set to cut different thicknesses, is essential; when cut by hand not only is the labour considerable but the slices are certain to differ in thickness from one another and even in parts of the same slice; this leads to serious irregularity in the salting and drying (thin slices or parts being over and thick ones under salted or dried) while the packing of the cans is uneven and unsightly. The guillotine slicer cuts every slice of similar and even thickness as determined according to the depth of the can.

57. The '*grilles*' in which the brined fish are placed are baskets of steel wire either tinned—which is preferable—or galvanized; they should not be of plain steel which rusts and discolours the fish. These grilles are so made that when horizontal the fish (sardines or mackerel) rest tails upward, on sloping wire partitions; draining is thus facilitated while the air circulates around and among the fish, rapidly drying off all extraneous moisture and slightly drying the tissues also. The fish when taken from the brine tubs are placed in these grilles which support them during both drying and the subsequent frying or steaming. Grilles sufficient for two days' work should be provided, since the grilles used on one day have to be cleaned. Grilles *must* be kept perfectly clean, and should immediately after use be boiled in water containing a small quantity of (caustic) soda so as to cleanse them of oil; soda ash may also be used, but is not so efficacious as caustic soda. After boiling, the grilles should be washed in fresh water and thoroughly and rapidly dried to prevent rust.

58. The *drying ground* is fitted either with a series of bamboo or other scaffolds from which the grilles are hung, or with open work tables (flakes) made of bamboo or wooden supports with cross pieces of wood or bamboo a few inches apart on which the grilles are placed so that the air circulates above and below and amongst the grilles; there may be both scaffolds and flakes on the same area, so as to economise space. If a drying room is used, which is necessary in rainy weather or at evening, drying is more costly and complicated, necessitating stoves or steam pipes with free or induced ventilation, or drying closets with a fan (preferably exhaust). Whatever form is used there must be provision (usually a fan or louvre ventilators and windows) for removing the moisture laden air; otherwise the fish will not dry. A stove so arranged

that only warmed air shall enter the room while the fuel gases pass direct into a chimney flue—which may however be of iron and led through the room so as to assist in warming the air—is a good arrangement, but there must be artificial ventilation, such as that of an exhaust fan, or a wide chimney or air flue, supplied with a stove, fire, or large lamp at foot to cause the necessary up-draught, to remove the saturated air. The subject is very complicated and requires a separate treatise with drawings.

59. In the *frying and packing* room the chief machine is the frier in which the fish, still in their grilles, are fried in oil at about 300° F. in order to drive off some of the moisture from the tissues, and thus 'firm' the fish which are otherwise liable to break up or 'mush' in the cans, and in order to sterilise them prior to packing. This frier consists of a metal vessel containing oil, usually of capacity to take two grilles of fish at a time. The heating of the oil is a difficult matter; if the oil is heated by direct fire the oil directly in contact with the metal is apt to be unduly heated, giving off acrid fumes by its decomposition, and may easily be scorched by the flames of the fire; moreover the debris of the fish falls to the bottom of the pan and scorches; hence the oil rapidly darkens and takes on a burnt flavour which is communicated to the fish so that the oil has to be frequently changed, and this causes considerable expense. Hence various methods to circumvent this difficulty; since in India open fires will be usual the heat can be modified and equalised by the sand bath method, viz., by placing immediately over the fire a metal trough in which there is a layer of clean sand an inch or so in depth; the vessel containing the oil is then placed in this sand bath and heated to the desired degree, fairly equally and without undue scorching, since there is no contact with flame.

60. Instead of a pan over a fire it is common and better to place the furnace at one end of the pan and carry the hot flue gases through horizontal tubes let into the pan and passing through the oil, which is thus heated more equally and with less chance of scorching; moreover the debris mostly fall between the tubes to the bottom of the pan which is, in this method, the coolest part of the arrangement. This necessitates several roomy tubes and a pan of sufficient length to absorb most of the flue heat. The tubes should be of *thin copper* which is more conductive of heat than iron and does not oxidize like iron; moreover when worn out

copper can be sold while deteriorated iron is valueless. The tube joints must be carefully brazed to prevent leakage; they should also be well tinned externally since the free acids in the oil are apt to attack the copper, forming deleterious compounds so that if not properly cleaned every day, there is a certain risk, negligible or non-existent in a perfectly well run factory but which may easily exist if the attendant or superior is negligent.

61. The best plan of all is that adopted in France, viz., to provide a deep pan with coned or taper bottom sectioned like a V with perpendicular sides above the V: the pan is filled with water to the top of the V, and with oil above the water. Through the oil are carried either the flues of a furnace as described immediately above, or, better, a series or convolution of steam pipes carrying superheated steam; by the use of steam the oil is readily heated without scorching, so that the oil lasts clean much longer than in any other plan. Moreover the debris from the fish drop through the oil into the water below and to the bottom of the V where they are innocuous and can be drawn off by a waste cock.

62. In the Beypore Cannery the sand bath is at present in use but it has always been intended to use steam when a superheater can be arranged, or the longitudinal flue system, heated, if possible, by a powerful kerosene horizontal burner from a Fletcher oil burner driven from a pressure reservoir; this has been delayed by the scarcity and high price of oil and want of the necessary arrangements; both will be tried this season.

A stand with a slightly sloping tray is placed next to the frier, so that the fried grilles may drain and the surplus oil return to the frier.

63. Instead of oil frying it is now common to steam the fish by the use of direct 'dry' steam. This involves a strong iron vessel or retort in which the fish are placed in their grilles and pressure steam turned on. At Beypore this has been successfully used for sardines which are sufficiently dried and sterilised by two or three minutes in the steam; this process is far quicker and less laborious than the oil frying, and though it is considered in France that fried sardines alone are first class, the method seems to be sufficiently good if extra oil is subsequently used (see below paragraphs 95 to 98 and 152 to 155); in America sardines are perhaps more generally steamed than fried.

The steamed fish being externally wet from the condensed steam have to be dried; this is readily done by exposing the grilles to the sun or placing them in a drier. In America huge rotary steam heated ovens are often used for drying or 'baking' the steamed fish: such oven consists of a vertical axle with horizontal shelves radiating from it; the whole is enclosed in a casing in which it slowly revolves: the grilles are placed on the shelves at an opening and remain in the oven during one revolution of the machine which usually occupies about 5 minutes; on re-arrival at the opening the grilles are removed.

64. The fried or steamed fish are then emptied from the grilles on to the *packing tables* which have been described above. Thence the packed tins, with covers inserted, are taken to the next room for closing either by soldering or by seaming. When closed they have to be tested for leaks; hence in this room there must be one or two testing vats heated either by open fire or by kerosene stove or by steam; if steam is available this is the best arrangement, viz., a vat of wood or masonry or metal with a closed coil of steam pipe at the bottom, over which is placed a perforated false bottom; see paragraph 101 for the method of testing. These same vats are used for 'exhausting' (see paragraphs 103—109) the tested cans: moreover, if the open pan processing system (see paragraphs 111—129) is used in the factory these or adjacent pans can be used for processing. These pans can be heated by open fire or by steam as is most convenient; steam of course is desirable since water is more readily and steadily heated than by open fire.

65. If the pressure system of processing is adopted there must be either one or two autoclaves or else retorts (kettles) steamed from an external boiler. As inferable from its name, the autoclave is self-contained and produces its own steam; it is a strong iron vessel, usually cylindrical and vertical, set over an open fire; in this vessel a moderate amount of water is placed and brought to the boil, and the cage (perforated metal cylinder) loaded with cans is then lowered into it; its cover is then secured steam tight and the fire urged so that the water in the vessel is driven into steam, which having no outlet, rapidly comes to the desired pressure. The cover is fitted with safety valves, a thermometer, and a blow-off cock. A geared hoist by the side of the autoclave is absolutely necessary to lift and lower the heavy cages. In the separate retort system a strong metal vessel either cylindrical and

vertical like the autoclave or rectangular and horizontal, is used; in this latter case the cans are placed on trollies which are run on rails up to and into the retort which is then closed steam tight and open steam is let into the retort.

66. Both these methods are in use at Beypore, but as operations are not very extensive the autoclave is generally used. The autoclaves may be of varying sizes, but usually hold 200 to 400 cans. The autoclave at Beypore measures 22″ in diameter and 29″ in depth and is now set in brick work over a wood burning grate; the brick work is banded with iron to minimise cracking and its effects; it has two cages (one being loaded while the other is in the autoclave), and each cage will take 380 quarter cans or 200 12 oz. cylindrical cans. It is well to have two autoclaves so as to deal with a rush of fish and to have one in reserve. The processing in such autoclaves (or retorts) may take an hour for each batch from start to finish, the actual steaming at the desired pressure being from 30 to 45 minutes according to the nature of the cans and their contents; hence in four hours two small autoclaves of 300 quarter tins each, could cook 2,400 such tins.

67. Retort steaming is somewhat quicker and as the retorts usually take more cans than the autoclave, a single retort suffices for, say, 4,000 quarter tins per four charges. The Beypore horizontal steam retort measures 72″ × 30″ × 30″ and will take 1,100 quarters. The trays of cans are piled on the trollies provided with the retort; these trollies rest on trucks (made at Beypore) which travel in a run-way to the mouth of the retort where the trollies are pushed inside on rails provided in the retort. The retort should be well lagged. When externally steamed retorts are used a separate steam boiler is needed which will also steam the steam frier (if such is in use). and the testing and exhausting vats and any other boiling pans when pressure cooking is not desired. Moreover, if there are power-driven machines the boiler is required by the engine. The size depends on the work to be done, but it is well to have a surplus of evaporative power, so that various items may be steamed at once. If a boiler with 6 square feet of grate is deemed *generally* sufficient it is well to buy one with 7 or 8 square feet to provide for 'peak' needs. The boiler should have a working pressure of 100 lb., for though only 11 or 12 lb. are needed in the retorts and the steam for the steam frier, if in use, is generally superheated, there may be machines to be driven, and in

any case, the surplus working pressure affords a margin of safety in case of careless attendants. The Beypore boiler is only 4 N.H.P. (about 4 square feet of grate) which will not steam the retort and vat and *simultaneously* drive the solderless plant or the 5 I.H.P. engine with a load.

Water should be laid on to the processing room not only to supply the autoclave and vats, but to provide for cooling the cans after leaving the steam kettles or the vats. It should of course be laid on to the boiler shed.

68. *Plant for fish pastes.*—Small but special plant is needed for fish pastes if those are manufactured. It will be best understood when the manufacture is described below (paragraphs 196—205) but consists of boiling pans or steaming chambers for steaming the fish, dishes, forks, etc., for removing the flesh from the bones, cutters with plates of various apertures for disintegrating the flesh, marble or slate topped tables for rolling out paste and ingredients, glass churns for mixing milk, melted butter, water, spices, etc., into an emulsion, stone mortars for further comminuting the paste, small grinding machines for grinding pepper and other spices, dried bread, etc., and so forth. The tins used are small cylindrical tins, capped or strip off as mentioned above, but with sets of small dies it should be easy to make small solid drawn tins in presses such as are available at Beypore, or semi-solderless cans with lock seams at side and seamed tops and bottoms; see supra *s.v.* 'sanitary' cans.

69. *Thermometers.*—At least half a dozen metal cased thermometers marking to 220° F. are needed for testing the water in vats; it is astounding how often water declared to be at testing temperature (say, 180°—190° F.) is shown by the thermometer to fall far below those degrees with consequent liability to spoil the testing, or how often when supposed to be boiling, is below 200° even at sea level. Several similar thermometers but reading up to at least 400° F. are necessary for testing the temperature of the oil in the frying vat. If it is desired to determine without doubt whether cans of given size and contents have reached the full sterilising or high temperature during processing, and to decide scientifically for what length of time and at what temperature cans should be processed, it is necessary to provide a number of small *self-recording* thermometers which can be wholly enclosed in the centre of marked cans and placed centrally in a batch; after processing, these

marked cans can be opened and the temperatures reached can be read off; it is astonishing how long it may take for cans to attain *at their centres*, the required temperature, and cans not fully sterilised at their centres necessarily spoil. It is well also to have a dry and wet bulb thermometer and to record the daily humidity which is an important factor in all fish curing and preserving. Hydrometers are necessary for testing the strength of the brine in the brining tubs; the Beaumé patterns, for fluids heavier than water, e.g., brine, are advisable.

70. *Graduated measures and scales.*—These, both large and small, are a necessity; tubs marked inside in gallons for holding brine, etc., pails and jugs marked inside with gallon or other marks, gallon measures for oil, graduated glasses for small measurements, handled oil measures holding exactly one ounce or other quantity for rapidly and exactly ladling packing oil into the tins. In very large canneries machines are provided which pass exactly the required amount of oil into a row of cans simultaneously; in Indian canneries this, at present, is hardly needed, as the canning maistry can readily supervise the supplying of one or two thousand cans by hand labour.

Scales are of course necessary at every turn; large platform scales to weigh the baskets and parcels of fish, scales for salt, for spices and condiments, for testing the packed cans to see if they are up to the standard, and so forth. Modern work requires exactitude, and accurate weights and measures are therefore essential.

71. *Miscellaneous.*—Skimmers for removing scum from brine tubs, from oil friers, or from testing vats, etc., are obviously needed; pincers of various forms and lengths for dealing with scalding hot cans when found leaky in the vats: the usual assortment of carpenter's or blacksmith's tools and appliances including a set of Whitworth taps and dies, are also necessary. Enamelled jugs and basins are required of various sizes, mainly large. For cleaning the oily cans as received from the cooker and before passing to the store-room, soda ash and whiting, etc., are needed, and for cleaning the grilles which must always be perfectly clean for fear of marking the fish with rust or dirt or flavouring them with dirty scorched oil, caustic soda is needed, in a weak solution of which the grilles must be boiled; this cleansing of the grilles is a most important item of work.

72. *Clocks.*—These are essential since the timing of the various processes, almost to the minute, is necessary, e.g., for brining, exhausting, processing, etc., apart from the necessity for timing the work of the operatives. Moreover it is advisable to have large dummy clock faces placed at the autoclaves, retorts, or boiling vats on which as soon as the pressure reaches the correct point or the water boils, the hands are set by the maistry to the hour and minute at which by the true clock the processing should cease; this prevents, or permits of checking, forgetfulness on the part of the boiling attendant. Similar clock faces should be placed on the brining tubs, in order to fix the time for removing the fish in each tub. These dummy clock faces may be of blackened wood 8″ or 10″ in diameter with white figures and movable hands. Large black boards in every room are also necessary, on which the Superintendent or maistry records the facts (nature and quantity of fish, time of receipt, etc.) of each batch of fish and the instructions for the operatives in charge of each important operation such as brining, drying, frying, preserving, etc.

73. *Labels.*—This accessory is of the first importance; the public judges—somewhat rightly—by appearance, for good appearance in usually means good method and good attention to details which turn connote good results. Moreover a neat artistic package argues superior supervision; a crude, glaring label or decoration suggests—not of course necessarily but it suggests—crude, poor-class ideas on the part of the Superintendent. During the war, labels had to be improvised from available material, but this was only accidental. In some canneries cans are made of 'decorated' tin plate on which while in the sheet, the required ornamentation and legends are printed; this gives a very neat and desirable appearance, while there are no labels to be lost or torn or fouled. These are mostly used for tinned sardines and the method can hardly be used for solderless plant. Hence, with the above exception, plain cans with labels are generally used, the cans being protected from rust and given a more or less attractive appearance by coloured lacquers. The labels may be of foil or glazed paper; if of foil they are either of a soft, very thin, flexible brass or of a flexible metal foil washed to look like brass. These on tin plate, whether polished as in soldered cans or matt (dull) as in a solid drawn can, look very neat, and if properly affixed are seldom lost, being protected by the overlapping edges of the cans. Paper

labels (glazed) must be artistic in design and lettering, and here the individual canner must select his own design, colours, etc.; he will do well to put himself in the hands of lithographic firms which make a speciality of this work. It is well to print the appropriate fish on the label and the *precise* character of the contents, place of manufacture, any guarantee, etc.; on cylindrical tins there may be room for appropriate drawings such as the one designed, from a local photograph, for the Government Cannery fish-paste tins. For cementing the paper labels to tin, it is necessary to use special paste or other adhesives; ordinary gum is useless as it rapidly dries so thoroughly that the labels come away from the tin; there are adhesives—sometimes with glycerine—which overcome this trouble. To avoid difficulty however it is advisable not to attempt to stick the paper labels to the can but to wrap them *tightly* round the can with an overlap; the two ends of the overlap are then gummed or pasted together, so that the label is kept in position not by adhering to the tin but to itself. Whatever labels are selected, they must be kept in separate labelled compartments in special lockers to avoid confusion and waste. It may be added that the goods must correspond precisely with the statements on the labels; it is both foolish and fraudulent to delude customers (temporarily) by glowing descriptions which are falsified by the goods themselves.

74. *Lacquer.*—A coloured spirit lacquer is often used externally both to protect the tins from rust and to attract attention. These lacquers can best be bought wholesale, but the simpler sorts can be manufactured, if so desired, within the cannery; a gold lacquer as applied to many cans of cereals, etc., received from England, gives a very neat and attractive appearance and entirely prevents rust, tarnishing, etc.; this can also be printed upon. In the Indian climate such lacquer entirely prevents rust. At Beypore the cans before leaving the observation room are smeared with a transparent varnish or lacquer which keep them from rust in all ordinary cases. Inside lacquering for protecting the contents is described above, paragraph 44.

75. *Rubber rings for solderless cans.*—These, whether pure vulcanized rubber or composition, rapidly deteriorate in this climate and, if long exposed to air in ordinary boxes, become perfectly brittle and useless. Hence they should be obtained in moderate quantities and packed by the thousand or so in separate

hermetically sealed tins; they will then keep good for a considerable time. Nothing is more dangerous either immediately or after a short space of time, than bad rubber rings. On the use of rubber rings and other sealing solutions see elsewhere (paragraph 40) in this bulletin.

76. *Disinfectants.*—These should be used freely for floors, walls, vessels, etc., but care must be taken not to use for tubs or other vessels for holding the fish, any disinfectants such as the carbolic (phenol) group which have a strong odour and which might affect the fish. For such vessels sodium hypochlorite solution may be used, the odour of which rapidly passes away as it does its work. The use of preservatives with fish is mentioned elsewhere, e.g., paragraph 92 and in the bulletin on fish-curing and preservation.

Material.

77. For fish canning, which in this section will alone be dealt with, these are—

(1) fish of various sorts,
(2) oils,
(3) condiments.

The *fish* generally associated with canning, except of course the salmon of the American and Canadian West Coast, are sardines, mostly put up in oil but also in various sauces and, in the Government Cannery, plain. Sprats or brisling are also canned in vast quantities as quasi-sardines; in America the young herring is also used largely as a quasi-sardine; in various places, herrings and pilchards (the latter being the adult of the true sardine) are canned; mackerel are canned in Ireland (for America mostly) and in America (U.S.A.); tunny is a very favourite fish in Mediterranean canning; prawns (called shrimps in the U.S.A.) are greatly favoured; crab meat, especially from Japan where the crabs are of huge size, is greatly in demand especially in the U.S.A.; Canada supplies the world with lobsters; oysters are canned to a vast extent; other fish are also in moderate use.

78. In India before the starting of the Government Cannery in 1911–12, only sardines were canned (in oil, tomato, and mustard sauce) and by a single French canner, M. de Josselin, at Mahē. The Government Cannery officers being struck by the comparative abundance of other cannable fish, at once began to experiment, and produced canned mackerel and canned prawns, both being

most difficult to can successfully, as well as various other fish in slices such as seer (cybium Commersonii), pomfret (Stromateus niger) bāmin (Polynemus), etc., besides oysters and mussels; various fish were also made into pastes. Following this example these fish are now being canned elsewhere. Since each fish differs from others in treatment, and methods are various for each fish, details will be given below where the canning of the several fish is dealt with and recipes given.

79. The trouble in India is that the fish, even though caught inshore, are often unfit for canning through delay and bad treatment on the boats and by reason of the Indian climate in which fish, 6 hours dead, are often unfit for food. Sardines and mackerel can be caught within a mile of shore but unless the first catch is large the canoes wait about for further catches; these if obtained are thrown on the top of the first catch which lies pell mell in the canoe; perhaps several hours elapse before the catch comes to shore by which time and under such treatment only the top layers (last catches) are fit for canning. Large fish may be caught some miles away and at night and are not brought ashore for some hours; since no fish are gutted or washed on board and since big fish are allowed to suffocate slowly in the bottom of the boat, it is common to find splendid fish already in the soft stage and unfit for canning. Hence unless factory or private carriers are employed or organized, so as to bring the fish in as soon as caught—which has the further advantage of enabling early and continuous work in the cannery—the cannery is often disappointed and its work curtailed not by want of fish, but by want of *suitable* fish. If a cannery is large enough and properly situated, it should employ carriers, motor or otherwise, to bring in supplies of fish rapidly and therefore in good condition.

80. *Oils.*—This material is an essential in sardine canning, and is a very difficult item in India. Properly speaking, sardine should be canned, as they were originally, in 'olive' oil, but this oil soon became far too expensive for all canned goods except 'articles de luxe'; moreover olive oil, as sold, is often very largely groundnut or other vegetable oil. In the United States of America other oils such as cotton-seed oil, are largely used, and in the Maine laws relating to canning, cotton-seed oil is taken as the standard oil, it being enacted that each quarter tin shall contain at least one ounce of cotton-seed oil or other oil of similar character. Here in India

we are at present practically shut up to groundnut and cotton-seed oils, and the latter, in quality suitable for canning, has of late been altogether unprocurable. The qualities required in oil are a good bright yellow colour, limpidity, freedom from all impurities and from any solid deposit such as stearine, from acidity and rancidity, and from marked specific flavour; it should be a practically neutral oil.

81. Pure *cotton-seed oil* freshly made from fresh seed answers these requirements, but is almost impossible to get at present in India. In pre-war days this oil was obtained from London of prime character and high class condition; it was mainly from fresh Egyptian cotton-seed, and cost from Rs. 2-14-0 to Rs. 3-4-0 per imperial gallon delivered in casks at Beypore. The lower class was used in frying and the higher in packing. Very fair double refined cotton-seed oil was at one time obtainable from Navasári in the Bombay Presidency, and single refined from Akola; at Cawnpore mills have been started to press and refine cotton-seed oil, but none has yet been available to the cannery demands. The Indian canning industry will be greatly assisted by the production of really high class cotton-seed oil in India.

82. *Olive oil* was obtained in bulk from England in pre-war days and then worked out at about Rs. 5 to Rs. 5-8-0 per gallon delivered at Beypore; present prices are very far above that, and the oil is practically not procurable in quantity.

83. *Groundnut oil* is a bland oil of high quality when pressed cold, but even so possesses a strong flavour which in the lower grades is very marked; this flavour is difficult to disguise or to banish. The ordinary oil as it comes on the market from the village presses, can hardly be used as it is; considerable refinement is necessary. A well-refined groundnut oil under the significant name 'olivine', has recently been placed on the market and is at present our stand-by in canning, but its price, even when ordinary groundnut oil was normal, was high and considerably above that of pre-war cotton oil.

84. *Coconut-oil* is out of the question; its strong and persistent characteristic flavour cannot wholly be removed, and when apparently removed, is apt to return on heating or exposure to air. Its use in margarine and vegetable butters is rendered possible by hydrogenation which removes all flavour, apparently permanently, but since this process hardens the oil into a solid white fat, it

cannot be used for fish canning, even if procurable in India. Coconut-oil refined by various other processes and pressed so that a white fat, resembling camphor in appearance, results at English temperatures, is merely a limpid colourless oil in India, with the usual coconut-oil characteristics. At present coconut-oil is impossible in fish canning.

85. *Til or Gingelly oil.*—This again, while an excellent cooking oil for all domestic use, has too strong a specific flavour for use in canning; possibly refinement might render it suitable, but no such refined oil is available.

86. *Sardine oil.*—At Tanur Government Yard very fine sardine oil is manufactured which is called A-1; this is light or bright yellow, almost free from acidity, and possesses but slight odour and flavour; the flavour indeed is largely that of the oily fish from which it is derived and which are those most desired for canning. This can always be used for frying, and an admixture of the same, in moderate proportion, with groundnut oil not only masks the specific flavour of the latter, but adds richness to the fish. But in using this oil only absolutely first-class yellow oil must be used, free from acidity and of slight odour and flavour, and the proportion must be moderate. When properly used the sardines are usually considered to have a better flavour than without such oil. Sardine oil similar in character to Tanur A-1 oil, is now made by several private factories on the West Coast under direct instruction from the Fisheries Department.

87. *Butter.*—Certain articles (de luxe) are canned in butter, but this is not used in India, and good oil is better than bad, adulterated or rancid butter which is too often the only sort available.

88. *Condiments.*—Under this head are included the spices and sauces used in canning fish. With sardines it is customary to add a clove, two or three black peppers, and a fragment of bay leaf with, sometimes, a sprig of thyme, in each tin; it has been found that cinnamon leaf (not bark) is an excellent substitute for bay leaf, which, however, is obtainable at Ootacamund where it is grown. In the United States of America mustard sauce (see recipes) is largely used, as also tomato. These are used in India also, but at Beypore curry powder with oil, a curry leaf, and ginger have been substituted for mustard sauce, and the products are largely sold. In all cases of the use of condiments it is for an intelligent superintendent to vary his recipes and mixtures to suit varied public

taste and not to adhere slavishly to a recipe even though considered 'standard'; many flavours are desirable to suit various palates.

For plain sardines, plain mackerel, etc., it is not usually desirable to add any spices beyond a few black peppers; salt, of course, is always added to all fish in the brining tubs.

For fish pastes the use of these and other condiments is usual, but every canner must find his own recipes and admixtures; some are given below.

89. *Maturing.*—It may be well here—though apparently out of place—to mention the advisability of maturing the cans of fish, since the admixture of fish with oils and condiments has been alluded to. All these several materials have of course their characteristic and very distinct flavour, whether fish, or oil, or cloves, bay leaf, etc. Consequently, when first mixed together, the contents of a can even after all ingredients have been cooked together in the closed can, are apt to taste crude and harsh, the separate flavours being quite distinguishable, whereas, after a few months in the can, the same will taste mellow, owing to the various flavours having blended to form a single combined flavour. In France respectable canners will not sell goods under many months from canning, and it is common to begin the sale of one year's pack when the next season's catches begin. This necessarily adds to the cost of the goods—for interest on idle capital, rent of stores, etc.—but greatly adds to their reputation.

The above only applies to fish packed in oil and condiments; plain sardines, mackerel, and prawns can be sold within 24 hours and with advantage.

CHAPTER V.

Canning Processes.

90. Before describing the passing of the several classes of fish through the cannery it is well to describe in detail the several processes common to all, with their objects and method; this will avoid repetition and render the subsequent narrative intelligible.

These processes are—

(1) Gutting, washing (and slicing if necessary).
(2) Brining.
(3) Drying.
(4) Frying.
(5) Packing.
(6) Closing (sealing).
(7) Testing.
(8) Exhausting.
(9) Processing (cooking).
(10) Observation, lacquering, and storing.

91. (1) *Gutting, etc.*—This preliminary is essential and urgent especially in India where fish are never gutted—even large ones—in the boats, where there is often delay in bringing in the fish, and where taint rapidly follows death. In order to hasten operations it is well to buy by weight or gauged baskets rather than by count as is sometimes done; this also minimises handling. Gutting may be carried out on piece work, but in Beypore, the women and children who mostly gut the fish, are paid by the hour, and they work hard because employment is desirable. Gutting, which always includes decapitation, is carried out on tables (see paragraph 55); if the fish are sardines and in spawn, the roes should be kept in the fish; with the larger fish it is usual to remove the roes and milts and to can or cure them separately. The gutted fish are thrown into baskets and sluiced in a tub or tank by shaking the whole baskets and contents in the water; this rapidly and effectually cleanses the fish which are then turned over for brining. Large fish have to be sliced for canning: this is best effected in ordinary canneries by a guillotine slicer (paragraph 56 supra) which, when set to the required gauge, shears the fish

into slices of even thickness, thus giving precision in salting, drying, and packing ; hand-cut slices are usually of irregular thickness even in the individual slices.

92. (2) *Brining.*—This is necessary not only to give the fish a slight savour, since saltless food is insipid, but to help in preserving the fish in the several stages before it is finally made safe by processing. In some cases, e.g., where fish are not sterilised by frying, it may be desirable to add a little boric acid or sodium hypochlorite to the brine ; these are innocuous and considerably inhibit (delay) taint so rapid in India. It must be understood that such preservatives are not added in order to disguise taint ; they cannot and do not do so, for a tainted fish remains dull of appearance and soft and pasty in texture whatever preservative be added. These innocuous preservatives are solely added—if at all—to *inhibit and prevent taint* while the fish is passing through various stages before processing ; it is a precaution on behalf of the consumer, not a method of deceiving or injuring him. Sodium hypochlorite, indeed, becomes sodium chloride, that is, *common salt*, in acting as a preservative. See section on 'preservatives' in the bulletin on "The preservation and cure of fish" of which a new edition will shortly issue.

In the matter of brining, the judgment of the superintendent or maistry is needed in fixing the period ; the weather (hot or cold, dry or damp). the time of day (since fish sometimes have to be kept after frying or sterilising, till next day if the hour is too late and fish superabundant), the condition of fish (large or small, fat or lean, whole or in slices), the tastes of the markets, etc., all have to be considered. A careless maistry will give the same time in brine to big or small, fat or lean sardines, or to whole fish such as mackerel and to slices in which the cut tissues are open to the brine on two sides. Brining is preferred to salting for canning fish since in any case the period is short—perhaps 20 or 30 minutes—and even fine salt would not sufficiently penetrate whole fish in so short a time ; there would be serious irregularity in the penetration of the salt if dry salt were used. Hence brining is general, and it is an axiom that brine shall not only be saturated at the start but kept at saturation point throughout, notwithstanding the continuous weakening of the brine by the moisture from the fish ; this is effected by an addition of salt in crystals to the brine which is thus strengthened by their solution. The frequent use of

the Baumé or other hydrometer or salinometer by the Superintendent is advisable; full saturation point is about 25° B.

Cut slices require very short brining, as the salt infiltrates very rapidly into cut tissues; five minutes is often quite enough, especially if the slices are less than one inch.

There should always be a good-sized (10 inches) clock in the room, since exactitude is desirable, and on each brine tub a dummy clock face may be placed to indicate the exact time for removal; with half a dozen tubs there is apt to be forgetfulness and confusion without some such aids. Separate batches of fish should not be mixed in the same tub; otherwise some will be over—and some under—salted.

A maistry should always be present in the gutting and brining room both to keep the people at work and to supervise the brining.

93. (3) *Drying.*—Since the fish are brined, and for other reasons, it is necessary to dry them rapidly. Hence from the brining tub they are thrown on a table and placed in grilles or wire baskets or wire trays (see supra *s.v.* 'grilles'). In the grilles the partitions are aslope at an angle of 45° from the vertical; hence by resting the grilles against the vertical frame work which runs down the centre of the table, the partitions become horizontal which facilitates the rapid and even placing of fish (sardines or mackerel) in the partitions; when the grilles are removed from the tables and hung on scaffolds the fish rest head downwards and drain freely. Slices of fish, prawns, etc., are best placed on wire net trays of a uniform size, and these are placed on flakes, i.e., skeleton tables or gantries which permit the air to circulate above, below, and around the fish. Grilles may be similarly supported, but it is found desirable to hang them by their ringed handles from scaffolds so that the air, however light the breeze, and the sun have absolutely free access to and play around the fish. In this climate, an hour or so in sun and wind sufficiently dry the fish for frying, but if frying or other mode of firming and sterilising the fish is not resorted to, a longer time must be given. As the fish are but lightly salted the drying process should be fairly rapid, and in dull, damp weather artificial drying must be adopted. The rooms and stores for such purposes have been described above (paragraph 49).

The fish should not be dried in the sense of curing-yard drying in which half or more of the moisture *in the tissues* is driven off; it is enough to drive off extraneous moisture and to render the fish

fairly firm so that it can be handled and packed without breaking; while a can of mushy fish is objectionable being liable to be thought decomposed, a can of over-dried fish is liable to rejection as hard and tasteless.

94. (4) *Frying.*—This operation, mostly confined to sardines though occasionally adopted for mackerel, tunny, etc., is an important and delicate one. The objects of frying are—

(1) to 'firm' the fish by driving off the *interior* moisture from within the tissues (the air drying is mostly to drive off exterior moisture) so that the fish may not only be readily handled and closely packed without breakage but will not be reduced to mere mushy fragments by the subsequent processing and transport to consumer;

(2) to sterilise the fish by a pre-cooking so as to arrest any chance of taint during the subsequent operations prior to final sterilisation by processing in the sealed can;

(3) to flavour and enrich the fish by contact with the hot frying oil;

(4) it may be added as a consequent of this pre-cooking and sterilisation, that many fish can be packed (and covered with oil) and then, if time does not permit of the cans being at once closed and processed as is ordinarily desirable, may be quite safely left till next morning for these final operations.

95. It is obvious that the nature of the oil used for frying and the method are of great importance; in domestic cookery delicate frying is considered the mark of a skilful cook; in industrial frying it is not less so. Yet it is not uncommon for this operation to be relegated to an ignorant workman who can spoil whole batches by bad frying. If the oil is fresh, clean, of high quality, of pleasant flavour, and uninjured in flavour and colour by any scorching of the oil or debris from the fish, of sufficient quantity and temperature (about 300° F.), the results should be good, but a careless cook or superintendent may allow the oil which necessarily becomes gradually unfit for frying, to pass the stage of fitness, in which case the fish are apt to taste of the scorched oil or be discoloured by the brownish oil or by over-frying. Moreover, he can easily hasten the scorching by inattention to the source of heat; an open fire or powerful kerosene stove can readily scorch successive portions of the oil so that the oil is rapidly spoilt. On the other hand the workman may change the oil too frequently and thus cause undue

expense; hence the need for watchful care and judgment on the part of both the superintendent and workman. It is better to be somewhat lavish in the changes of oil rather than the reverse, for the used oil can be sold at a fair price to boatmen, etc., for caulking boats, especially if the oil is fish oil; while a batch of fish flavoured or coloured by scorched oil is necessarily bad or inferior and detracts from the reputation of the cannery.

The oil generally used in India is one of the vegetable oils especially cotton-seed and ground-nut; these ought to be, but at present are not easily or cheaply procurable. The Tanur A-1 sardine oil is very good for frying and in no way injures but rather improves the flavour of the sardine or other fish: private factory oil of similar quality is now procurable and may be used if perfectly clear of impurities and not rancid.

When frying fish the oil should not be allowed to pass beyond a moderate brown colour as viewed on pouring it from the ladle; it should not be opaque, dirty, or scorched.

96. It is also obvious that the method of heating the oil is highly important. If heated by the flames of an open fire or powerful oil stove, scorching may result from undue forcing of the fire even for a short period. Hence various modes of heating have been adopted, for which see 'plant,' paragraphs 59—63 supra. Where open fire is a necessity the sand bath is fairly successful in minimising scorching, but the fire should be maintained at a very equal and regular heat, and charcoal or coke may usefully be burned; dry wood flames rapidly and rapidly dies out. Gas, which can be turned to a particular height and kept precisely at such height, gives the most favourable form of open heat; oil stoves of the "Primus" or other pressure system supply a fairly regular heat, especially if the reservoir is large and pressure considerable, so that the flame can readily be regulated and then kept for long periods at the desired height.

97. On placing the grilles in the oil, there is considerable foaming due to the rapid vaporisation into steam at 212° F. of the moisture in the fish by the great heat of the oil at 300° F.; there must therefore be a certain margin between the surface of the oil and the rim of the pan. The grilles are kept for about a minute in the hot oil; a little more if the fish are large; as soon as the fish begin to rise in the oil they are sufficiently cooked, because this means that so much moisture has been driven out of the fish that

they become light enough to rise in the oil. It is well to keep a thermometer (capable of marking up to 400° F.) at the pan, so as occasionally to test the temperature of the oil.

The grilles when removed from the oil are placed on a sloping surface adjacent to the frier so that the surplus oil may drain back again.

There should be a rack close to the frier, so that the grilles of raw fish may be stacked there from the drying ground and be ready to the operator's hand; this saves confusion and waste of time.

98. Instead of frying fish in oil resort may be had to 'baking' the fish either by hot air in an oven or by 'dry' steam, see paragraph 63 supra. Sardines have been successfully steamed in the Beypore factory; the process is very rapid and cheap since 30 or 40 grilles can be steamed in two or three minutes and there is no expenditure of oil; the steam being at a high temperature and containing also a vast amount of latent heat, drives out of the fish, when condensing upon it, a quantity of the interior moisture by vaporising it in the shape of steam; the fish when taken out are found to be thoroughly cooked and firm and bear packing and transport perfectly well; it is only necessary to re-dry them for a few minutes in the sun or in a drier to drive off the moisture condensed on the surface of the fish. But for steaming a proper arrangement is necessary so that the steam shall be *dry* and the fish readily accessible; it is understood that in America a continuous method is available.

Two precautions, however, are necessary in steaming:—

(1) that the steaming be not continued too long, for in that case the flesh is apt to become unduly dry; the length of time should probably not exceed 1 minute for small sardines from the time that the temperature exceeds 212°, and 2 minutes for larger ones;

(2) that in packing steamed sardines in oil 25 to 50 per cent more oil should be used than with fried sardines in order to supply the fish with the additional oil which fried sardines retain on their surfaces and absorb; or the fish may be dipped, or bathed for a few minutes, in fresh, pure oil.

If these precautions are observed steamed sardines may be as good as the best fried sardines; otherwise they are undoubtedly inferior.

99. (5) *Packing.*—It is assumed that as soon as a batch of fish (sardines and mackerel, etc.), comes in, the superintendent orders

the number of cans that will be required, and that the maistry obtains these cans from a stock kept ready and clean for use ; it is not good business to begin to clean the empties when the fish have already arrived. These empties are then ranged on the tables in the packing room, and the oil and condiments required are placed in proper quantity in the cans ready for the packers. The superintendent will have determined the character of the packing on his knowledge of the goods required and the nature of the fish.

Packing is done by women and children, and the precise mode depends on the shape of the can and the size and character of the fish. The quantity of oil, usually in the neighbourhood of 1 oz. for a quarter tin of sardines, is determined by the superintendent and maistry, and depends largely upon the fatness or leanness of the fish. Much judgment is here needed, for stinted oil often means spoilt fish, while on the other hand an excess of oil is mere waste if the fish are fat ; moreover if the tins are packed too full, much oil is squeezed out in pressing down the covers, especially if the tins are solderless and the covers deeply dished and very forcibly pressed down by the double seamer. There must always be due proportion between the fish and the oil, so that on the one hand the fish are packed sufficiently closely to prevent movement in the can and to give the consumer good value, on the other to give room, where oil is used, for a sufficiency of oil to enrich the fish and utilise the flavour of the condiments.

As mentioned above *s.v.* frying, packed tins of fried and sterilised fish can, if covered with oil, be kept over till next morning if the rush of work entirely prevents the final closing and processing of the cans.

100. (6) *Closing* (*Sealing*).—This has been dealt with above paragraphs 24—43, and is a purely mechanical process whether soldering or seaming. The only necessity is that the work shall be done with the utmost care ; in soldered cans that the solder shall be of good quality, the edges of covers and bodies clear of rust, the flux non-poisonous, e.g., rosin, and the solder applied neatly and rapidly with due economy yet without leaving the smallest pin hole. In the case of solderless tins the rubber or composition washers or the sealing solution must be continuous and evenly affixed to the covers, elastic and not hard or fragile, the double seamer perfectly adjusted, and the attendant sufficiently skilled to give the machine its full closing value ; it is easy to

spoil the closing of solderless tins by undue or uneven pressure in a badly adjusted machine.

101. (7) *Testing.*—The success of the sealing operation is readily tested. The closed cans are placed on edge in rows in wire baskets and plunged into water kept at about 180° to 200° F.; the temperature should be nearly that of boiling but without the disturbance caused by ebullition. The strong heat of the water expands any air within the can and, if there is even a minute aperture, within a few seconds the air forces itself out in a continuous stream of bubbles which is readily detected; any such can is at once lifted out with proper tongs, marked at the defective spot and sent at once to the solderers for repair. If the tin is solderless, a second passing through the double seamer may possibly cure the defect. There is no impropriety in passing cans as good which have thus been reclosed before processing; the leakage has not caused decomposition or been discovered by such decomposition but is a mere petty defect in sealing discovered at the very instant after sealing. Since each can bears the private mark of the solderer who made the empty can as well as the solderer who sealed the packed tin, the responsibility for bad soldering is easily determined. It is here that the solid drawn solderless cans have a great advantage over soldered tins, viz., that there is only one seam to leak, that which unites body to cover; hence only one source of leaks as against three (top, bottom, and side) in ordinary soldered cans.

If no leaks are detected within a minute or so at a temperature of or above 180° F. the cans may be passed as primâ facie sound.

102. Canners are frequently puzzled by cans going wrong in store, though they have successfully passed the testing vat. This may be due to leaks from causes such as—

(1) subsequent straining of the joint in processing or at the close of processing (see below paragraphs 115—126 *s.v.* 'processing');

(2) weak soldering or the giving way of soldering at a rusty point;

(3) a hole so minute that the pressure within the can has not sufficed to drive the air visibly through it at the moderate temperature and consequent air pressure attained by the can in the testing vat;

(4) a minute leak being temporarily closed by the expanded air forcing into it a morsel of the contents;

(5) decomposition from bacterial or enzymic causes even yet unknown or obscure or from action of the contents on the metal, etc.

It is to be remembered that a hole so minute that the finest needle point cannot enter it, is of ample size to admit bacteria readily, and that since a partial vacuum is caused within the can when it eventually cools (as shown by the concavity of good tins) the outside air, laden with germs, is gradually sucked into the can through such hole, and decomposition then sets in.

103. (8) *Exhausting.*—This is in general a necessary process and may be made practically continuous with testing by simply raising the temperature of the testing bath ; exceptions to exhausting will be mentioned below. Exhausting is the removal from a can of free air for physical and business, not bacteriological, reasons, viz., to prevent undue pressure within the cans during or immediately after processing ; its object is not sterilising though this partially results. When air is left in a can as must be the case in cans of plain sardines (without oil), or mackerel, or sliced fish or prawns in a cylindrical can, this air expands when heated, and if heated above boiling point so that steam also forms within the can, the internal pressure may easily disrupt minute weak places in the seal or even burst the seal. Moreover, if the tin plate is thin it may be distorted or buckled by the internal pressure and become what is called a 'springer' or 'flipper' simulating a 'swell' or 'blown' tin. For instance, a can sealed at 50° F. and not exhausted, may, when heated to 212° F. have to bear an internal pressure from the expanded air alone, of about 18 lb. per square inch, a pressure which is hard for tin plate and for seams to withstand. Moreover if the can is processed under pressure and raised perhaps to 240° F. the pressure inside the can rises still higher both from the expansion of the air and the formation of steam ; so long as it is being heated in the retort, the external steam pressure balances the internal steam pressure, but on blowing off the steam this *external* pressure is removed, and the can has therefore to bear the whole internal pressure due to the contained and highly expanded air and steam. This may easily cause leaks in strained seams, and it is therefore necessary to remove most of the air and thus reduce so much of the internal pressure as arises from the expanded air. Again, even if the can remains sound and normal it will, if full of air, swell and take on a slightly bulged appearance when transported to a place

warmer or at a greater elevation above the sea level than the place of canning, so that the retailer or consumer suspects or rejects the can to the detriment of the canner in purse and reputation. See paragraphs 136—139 on 'swells' and 'springers.'

104. By exhausting the air these risks are largely removed, and since the removal of the air causes a partial internal vacuum, the tops and bottoms when at normal air temperature, assume a *concave* shape : *this is the test of a sound can*, and since cans which are unsound speedily bulge and become *convex* on *both* sides, exhausting enables one to distinguish at once between a sound and an unsound can. Hence the objects of exhausting are to remove much of the expansible air and thus prevent risks by internal pressure to the soundness of the seams and to the due 'set' of the tin plate, to cause the cans to become concave at normal temperatures, to prevent temporary convexity ('swelling') at somewhat elevated temperatures (e.g., at the temperature of 120° F. in some places in the hot weather as compared with 85 to 90° F. at the cannery) or at elevations perhaps 7,000 feet above the place of canning, and to enable the instant differentiation of sound and deteriorated cans.

105. Since the removal of the air is the main point it follows that cans packed *full* of sardines in oil, need not be exhausted; there is so little air in them that it may be neglected; so also the solderless cans at Beypore need no exhausting because the mechanical pressure of the dished cover removes practically all air.

106. On the other hand very large tins of fish (other than tins of sardines in oil filled to the very brim) may easily be exhausted too much ; a kerosine tin of fish may, when highly exhausted assume a battered and ugly appearance and may even collapse under external pressure ; hence large tins, if fully exhausted, must be of strong material and seams. Nor is it necessary or advisable to exhaust cans too thoroughly when they are loosely packed as with salmon, mackerel in cylindrical tins, slices, etc. For if too thoroughly exhausted of the air and filled entirely with steam, it follows that on cooling and consequent condensation of the steam there would be a very high vacuum, which would not only endanger the seams by the ordinary atmospheric pressure, but would facilitate the indraught of air with its attendant bacteria through a hole or porosity in the metal or seam so excessively minute

as not to be ordinarily detected or to get into operation very slowly; it is possible that many of the mysterious swells which occur after months of storage may be due to this slowly operating cause.

107. Exhausting may be variously effected, e.g., by placing the cans, properly arranged in wire baskets, in boiling water; the cans are provided with a pin hole vent in the cap, and after a few minutes sharp boiling, the baskets are removed and the vents sealed with a drop of solder; this is known as 'tipping' the cans. This method is generally used for tall cans, so that the vents may be above the water. But cans of all sizes and shapes with open vents may be exhausted in a steam retort; the trollies of cans are run into the retort, left there for a few minutes, again run out and at once sealed while hot. In both cases the cans and their contents are very hot and the air is highly expanded, so that if tipping is *smartly* effected the external air will be quite sufficiently excluded from entrance. In the Beypore cannery and probably in most fish canneries where mechanical exhausting is not practised, the cans of every kind are sealed without a vent, and then submerged entirely in boiling water or placed in the steam retort (at low pressure); when removed (usually slightly convex in shape), they are at once pricked with a fine punch so as to form a pin hole vent through which the air and steam escape with a sharp hiss; they are then at once tipped by the solderer who immediately follows the venter. In large canneries a conveyer takes the vented cans slowly and continuously through a steam box on emerging from which the vents are sealed.

In the Beypore cannery exhausting is practically continuous with testing by simply bringing to the boil the water of the testing vat as soon as the cans under test have satisfactorily passed.

108. The most modern method is exhaustion by mechanical means: an exhausting vessel usually of corridor shape, is so arranged that the vented cans pass through an air-lock into the exhauster which is kept at a considerable vacuum by connexion with an air pump and consequently sucks out the air from the cans through the vent; at a certain point the cans pass slowly under an electrically worked soldering iron within the exhauster and the tipper is thus enabled to seal the cans while still in the vacuum.

109. Whatever the mode adopted the exhausting should be such that so much of the included air is expelled or sucked out that the tins when processed shall be subjected only to moderate internal

pressure, and shall when cooled show a permanent but slight concavity in top and bottom.

The above remarks deal principally with the ordinary exhausting of fish cans.

110. In the case of articles such as jams, poured boiling hot into cans and then sealed, exhaustion is not necessary; the head space between the cover and the surface of the hot jam, etc., is only 1/8 inch and the air and aqueous vapour at, say, 180° F. are of such tenuity that a sufficient vacuum will be formed when the can cools. Glass jars used for fruit and other preserves which are either poured into the jar at boiling point or are heated in the jar to that point, need no exhaustion as they are full of steam when ready for closing, so that a vacuum is necessarily formed on closing the jars by the usual sealing cap. Moreover, being glass jars, one main object of exhausting, viz., the result on the shape of the tin, does not exist.

111. (9) *Processing.*—Here we enter on the final and most important of the actual canning processes. A can under-processed will go wrong; it may go wrong if internal and external pressures are excessive: it will be unsaleable if over-processed so that the contents are scorched or over-cooked or if the tin plate is swollen or battered. But without processing (cooking) of a correct sort, general canning is impossible, for processing means the complete sterilisation (destruction of the bacteria) of the contents of a can *after* they have been hermetically sealed in a container in such way that no further access of bacteria is possible; if the bacteria or the spores of such bacteria already within the container and its contents are not utterly destroyed, the contents of the can must go bad. Moreover, it fortunately happens that the toxins and ptomaines which are the products of bacterial activity are mostly destroyed by strong heat, especially when, as in pressure processing, the temperature much exceeds (rising to 250° F.) that of boiling water. Hence the need for careful and thorough processing.

112. In the making of certain canned goods such as jams and bottled fruits, the contents are either poured boiling into the containers and then closed up, or they are placed in the containers and brought to the boil and hermetically closed; in these cases the cooking is not a separate processing. This method will not here be dealt with, but it may be remarked that when the contents

are poured boiling into a jar or container and then at once sealed up while hot, it is well to turn the container upside down for a time so that any air left in the head space between the contents and the cover, is forced to pass up through the boiling contents and is thus sterilised.

But in the bulk of canned goods, processing is a separate and final operation.

113. Processing, then, consists in raising the temperature of the *entire* contents of a can to above sterilising point. For fruits this may be somewhat above the pasteurising temperature, say 170 to 180° F.; over-processing in such cases may break up the fruit unduly. Nearly all bacteria are destroyed by such temperature but spores are not; since certain of these are liable to be found in fish and meats and vegetables the temperature should always be raised to full boiling point (212° F.), and the higher temperature of pressure steam processing is desirable; this may rise to 240° F. (11 lb. pressure) or 250° F. (14 lb.). The conductivity of the contents of a can differ greatly, not merely by reason of their nature (e.g., air, water, fish, meat, etc.) but according to their solidity or porosity; moreover, it obviously requires much longer to raise the centre of a large can to the desired point than of a small one, and unless the *very centre* of a can is sterilised the whole operation is useless and mischievous. Hence the canner requires great experience and judgment in the time allowed for processing; for instance, a can of prawns packed wet, i.e., with brine, requires a much shorter time than if packed dry (with consequent large air spaces) because water rapidly heats up owing to the convection currents set up in liquids on being heated, so that all parts of such liquid are continuously on the move and are brought successively into contact with the hotter part (walls) of the can; hence rapid and equal heating; air on the other hand is more or less stationary and conducts badly. A 2 lb. requires longer than a 1 lb. one; a flat can of shallow depth and large superficies gets heated to its centre more rapidly than a more compact one; a can of solid paste heats slower than a can of oysters which contains much fluid, and so on. One corollary from this is that in steam processing where the vessel is closed steam tight, it is impossible to process cans of different sizes and even contents (if radically different) at the same time; in an open vat this can be done since cans can be removed at pleasure. But to avoid confusion, it is better to sterilise only

goods of same size, contents, etc., at the same time, even in the open pan.

114. Until standard periods for the several cans of various sizes and contents have been arrived at by experience, some losses must be expected. It is well, during such time, that the canner should, especially where work is more or less experimental, adopt the plan of enclosing small recording thermometers in the *centre* of the marked cans and thereby ascertaining whether the entire contents have reached the desired temperature; meanwhile the paragraphs below dealing with the various classes of goods, will give approximate standards.

115. The methods of processing are widely different and must be selected on a consideration of conditions; all will, if properly conducted, give perfect results in sterilisation, but all are not equally convenient under different conditions. The first and most simple method is that of processing in plain water in an open pan; in this method the temperature cannot possibly rise above 212° F. and in case of large cans of poorly conducting contents the cans have to be cooked for a very long time. This not only wastes time and demands several boiling vats in simultaneous use if the cannery or rush of goods is at all large, but is apt unduly to cook the outer layers of the contents while the heat is penetrating to the centre; for ordinary sardine quarters the period of boiling from the time that the actual boiling point (212° F.) is reached in the vat may be 1½ hours. But the method has the great advantage for a small cannery of requiring the simplest and cheapest of plant; any metal pan over an open fire will readily effect the necessary cooking, nor is any expensive boiler attendant necessary. Other advantages exist, especially the fact that no strain is put on the joints or seams by the *internal* generation of pressure steam; the internal pressure is due solely to the expansion of any air in the can and if this has been properly 'exhausted,' or if the goods are merely sardines in oil, the internal pressure is inconsiderable; hence much fewer leaks than where a high temperature and pressure are adopted, unless great care is exercised. Another advantage is that testing, exhausting, and processing may be continuous in the same vat, so that much time, labour, fuel, etc., can be saved. One further advantage is that when the processing period is over, the ebullition is stopped and if any of the cans are then leaky the fact may be discovered before removal of the baskets from the boiling

pan. Moreover by having two pans side by side, the processed cans can be removed from the boiling pan into its neighbour which is filled with cold water; this cools the cans, which is desirable, and at the same time heats up the water ready for a processing operation in this second pan, and so alternately.

116. If steam is available a pan, which may then be of wood or masonry with a steam coil in the bottom, may be usefully substituted for the open fire; the coil may be closed or open, the latter having the advantage of utilising the whole heat of the steam: moreover, the condensed steam supplies a quantity of pure water to the vat; in either case the coil should be placed below a stout perforated false bottom on which the baskets of cans rest. The temperature of course can never rise in the open vat beyond 212° F.

117. But it is often, perhaps generally, desired to process fish (also meat and vegetables) at a temperature above 212° F. so as to kill sporing bacteria and their spores and destroy toxins. Moreover, this method saves two-thirds of the time in processing, and consequently needs less space than the open vat system, since a single retort will do the work of several open vats. This rapidity of action is due to the fact that not only is pressure steam of a higher thermometrical temperature than boiling water (the temperature rising according to pressure so that steam at one atmosphere (14—15 lb.) marks 250° F. on the thermometer), but steam contains a large amount of 'latent' heat; water in passing into steam absorbs 966 units of heat, so that while boiling water at 212° F. contains 180 units of heat, steam at 212° F. contains 1146. Hence when steam is brought into contact with the comparatively cold cans, it condenses and in condensing gives up its contents both of latent and thermometrical heat to the can. Hence the can is far more rapidly heated up by steam at even 212° F. than with water at that temperature, and still more so at 220° F. or higher temperatures. Consequently it is usual, where possible, to process cans of fish, meat, and vegetables (which latter frequently contain sporing bacteria) by pressure steam. As mentioned above (paragraphs 65—67, etc.) this may be done in autoclaves raising their own steam within the vessel by means of a fire below it, or in a plain retort steamed from an external generator.

118. There is more than one way of steaming cans; sometimes the vessel is filled with water until the cans are nearly covered; the cover is then clamped steam-tight and the fire urged or steam

(in a *closed* coil) turned on, till the required pressure is reached; as the water expands slightly by heat, it should not do more than nearly cover the cans. This method not only prevents scorching of the cans by the hot jets of steam playing on the outside but the convection currents in the water cause rapid heating; moreover, not only does this water bath permit more gradual heating and consequent more gradual increase of pressure, but also at the close of the operation when steam is turned off and the escape opened, the water, remaining at boiling point, allows a more gradual lowering of the temperature within the cans and minimises the chances of leaks by the sudden cooling of the cans which is caused when the cool air from outside suddenly enters the retort. Similarly, in autoclave processing it is possible that instead of placing only a small quantity of water in the autoclave, enough should be introduced so as nearly to cover the cans when inserted in their cage, so that the cans would be processed by superheated water rather than steam, at the required pressure; this water would surround the cans when the operation is over and prevent the sudden access of cold air. If the kettle is steam heated the water bath is of course heated by a *closed* coil so as to avoid excess of water from the condensation of open steam.

Where, however, as is most general, the water in the autoclave only suffices partly to fill the autoclave, or the cans in a retort are exposed naked to steam from an outside generator, various precautions must be observed—

(1) to cause circulation of the steam;

(2) to prevent injury to the soldered seams by the sudden pressure of high temperature steam at the beginning of the operation;

(3) to minimise the occurrence of leaks or development of 'springers' by undue and sudden internal pressure when the steam is let out and the retort opened. This point refers only to *soldered* cans packed comparatively loosely, as with mackerel, which contain a good deal of air and moisture; it does not refer to solderless cans or cans with locked seams, and is of no material importance to cans of fish such as sardines when packed in oil.

119. On the first point it is only necessary to keep an escape cock slightly open ('cracked') or the safety valve slightly blowing throughout the operation; this causes rapid movement instead of comparative stagnation of the steam, and both hastens and equalises processing; without such precaution it is found that cans

especially in corners of the steam retort or in the centres of close masses of cans, are unequally steamed.

120. The second difficulty is turned by letting the steam on gradually, so that the pressure gauge mounts slowly ; this not only prevents the hammer-like blow of high pressure steam impinging suddenly on the naked cans, but tends to bring up the internal pressure within the can *pari passu* with the external pressure, and thus minimises strain.

121. The third matter is more difficult and complicated. It has been shown that there is always, except in tins closely packed and filled with oil, a certain amount of air even after exhausting—as well as some moisture in the fish ; hence on the application of a temperature above 212° F. there is considerable expansion of air and vapour within the can ; cans when removed from steam kettles or retorts are visibly and even heavily bulged. The expansion and consequent internal pressure due to air plus steam may be many pounds to the square inch when the temperature has been raised to 240° F. with its corresponding steam pressure of 11 lb. ; hence if at the close of the processing the steam is turned off and rapidly blown off by the vent cock and safety valve, the cans in which, ex-hypothesi, the same temperature and even higher pressure (due to internal air) have been reached, remain at that pressure, and this being no longer partly balanced by the external pressure causes sudden and considerable bulging which the joints may not be able to stand, or which, especially with very thin tin plate, may so buckle the plate as to permanently distort it and cause 'springers.' Supposing the retort temperature to be 240° F. or 11 lb. pressure, this is consequently the minimum pressure within the can when fully processed, to which must be added the pressure from any expanded air ; if the can is not completely exhausted (which it never is and should not be, since there would then be an unduly high internal vacuum, see supra paragraphs 103—109) this adds considerably to the internal pressure.

122. Hence the tendency to leaks and distortions. This danger can only be slightly overcome by blowing off the external steam gradually, for the cans, in bulk, retain their full heat for a long time and consequently the internal pressure must eventually exert itself ; all that can be said is that the effect is gradual and not sudden, but this is counterbalanced by loss of time and by probable overcooking of the goods in remaining too long at a very

high temperature. That this overcooking is no slight difficulty is shown by the fact that it is usual to cool the cans by jets of cold water after removal from the retort so as to prevent overcooking; this of course does not get rid of the difficulty now under consideration, viz., the necessary internal pressure which exists as soon as the external pressure is removed by blowing off the steam.

123. It has consequently been sought to cool the cans while in the retort and still in the steam by introducing cold water; this seriously aggravates the difficulty, for the cold water condenses the external steam and causes a partial vacuum, so that the internal steam pressure is now 11 lb. plus internal atmospheric pressure due to the existence of a partial vacuum in the retort; assuming this to be 7 lb., the total internal pressure tending to burst the seams, will be (11 plus 7) 18 lb., a strain much too heavy for many soldered seams.

124. A feasible method would seem to be that of supplanting the steam in the retort by air condensed to the same (11 lb.) pressure; the pressure in the cans is thus balanced by external air pressure, and as the air does not condense like steam it is then possible to introduce jets of water to cool the cans while within the retorts; this not only reduces the internal pressure to normal but prevents overcooking.

125. In all the above remarks both as to exhausting and its reasons and to processing and its difficulties, only such cans as normally contain considerable air and moisture and which have *soldered* and lapped seams, are contemplated, the objects being to minimise leaky joints and buckled plates in such cans. Cans which are normally filled perfectly full of oil and fish and compressed by well fitting dished lids, or which are made with locked seams and double seamed instead of being soldered, are not seriously affected by these particular processing troubles, especially if the cans are, as at Beypore, solid drawn and have only the one seam, viz., that joining body and cover. Sanitary cans, double seamed at top and bottom, and with locked and soldered side seam are probably safe from all but extraordinary strains, but when in fish canning these cans are tall cylinders comparatively loosely packed with chunks or slices of fish or whole fish such as herrings or mackerel, good exhausting is highly necessary to avoid processing troubles and to ensure the required concavity in tops and bottoms.

126. Where steam is not available but it is desired to process at temperatures above 212° F., it is necessary to heat the cans in

open baths of some solution such as calcium chloride or of oil which can be heated much above 212° F. without boiling; hence cans placed in such baths can be raised above 212° F. without steam plant. This plan is very easy and successful for cans such as sardines in oil, for in such cans there is, ex-hypothesi, little or no air and very little moisture, the cans being fully filled with fried fish and oil Consequently, however, high the temperature of the bath there is no internal pressure within the cans nor, being boiled in an open pan, is there any external pressure. Hence this process is quite safe for cans full of fish in oil. It may be otherwise where *soldered* cans have considerable internal air spaces and a certain amount of fluid or moist contents; for in such bath it is obvious that any internal pressure due to expanded air or to the formation of steam within the cans is exerted to the full and throughout the operation without any counterbalancing pressure from external steam; hence the strain on the joints is continuous and may frequently result in leaks and distortions of tops and bottoms, and may even burst the seams. The danger of scalding may of course be minimised by properly covering the cans and pan with heavy wooden or other covers, but this does not remove the possibility of leaks, etc. The process was at first in favour, and then grew into disfavour; it is said to be now reasserting itself, possibly because soldering is giving way to mechanical closing by locked seams. The calcium chloride solution or oil will give any necessary temperature; oil has the disadvantage of expense and of giving off fumes, especially if heated by open fire, but has the advantage of not evaporating; chloride of calcium is very cheap and fumeless but the water rapidly evaporates and has to be constantly supplied; hence a tendency for the bath to rise unduly in temperature with the density of the solution and consequently to over-heat the cans unless carefully watched and corrected, e.g., by a small continuous addition of water, supplied automatically at a given rate from a supply vessel. It is said that slight discolouration of the tins is caused by calcium chloride; experiments at Beypore do not show any such appreciable result; oil, of course, does not discolour the cans. The advantages of these high temperature open baths are considerable where steam is not available.

127. It is well to spread out the processed cans on the floor immediately after removal from the kettle and douche them with

cold water so as to reduce the internal pressure as soon as possible and to prevent overcooking.

As regards overcooking; this is not so important in the matter of fish as in the case of fruits, which are easily spoiled by undue processing either in the degree of temperature or length of process.

128. Where sporing organisms are found or suspected in the goods, it is the practice to minimise danger to the goods by fractional sterilisation; the cans are processed on two or even three successive occasions at 24-hour intervals; the first processing kills the existing mature bacteria, and the second kills those which mature from the spores of the previous day. But it is not a satisfactory method, as the goods are apt to be overcooked; in the case of mackerel, canned plain or marinated (in spiced vinegar), the flesh may become unduly dry and insipid, the natural fluids having been boiled out and remaining in the fluid found on opening the tin.

129. It appears that for *small* canneries where the output does not warrant the expenses of steam processing, viz., an expensive boiler, retorts, and autoclaves, and skilled boiler attendants who are necessary even for pressure autoclaves, the open pan method is preferable to pressure processing, owing to the advantages mentioned previously, such as cheapness of first cost, simplicity, cheap running charges, absence of danger of explosion, ease of operation by the combination of testing, exhausting, processing, and retesting in the same pan as an almost continuous operation (see paragraph 115), absence of strain on the soldered seams, etc. The main disadvantages are slowness of operation, which does not always matter, and inability to obtain temperatures higher than 212° F.; even this can be got over by using calcium chloride or oil baths.

Final testing.—This is mainly necessary after pressure processing because, as has been explained above, there are heavy strains internal and external on the seams, especially dangerous to them when soldered; hence pressure processed cans should be again tested. This is readily done by placing them in trays and lowering them into an open vat of hot water, just below boiling point, when any leaks can be detected by streams of bubbles; this, of course, is still more simple when processing is effected in an open vat; see paragraph 115. Such cans may be re-sealed at once and re-processed, being of course as safe as any other can.

130. (10) *Observation, Lacquering, and Storing.*—From the processing room the cans are removed to an observation room; in temperate climates this is warmed to say 80° or 90° F. so as to promote bacterial growth and thus detect any defective cans. The cans are placed on racks, tables, etc., in rows for the ready detection and removal of blown cans, and kept there for a week or so. Meanwhile, since the cans are greasy and dirty it is customary to have them cleaned while in this room; plenty of sawdust or paddy husk, cloths, whiting, etc., are needed, and when the cans are clean and bright it is well to lacquer them to prevent rust. At Beypore a transparent lacquer is used which is found efficacious in preventing rust; but if a coloured lacquer is to be used for permanent colouring it would be well to apply it here; such coloured lacquer is applied by dipping the cans, held by a convenient forceps with pointed grips, into the coloured spirit lacquer, and placing them on spiked frames where they rapidly dry; the points prevent the sticking of the cans to their supports and thus losing lacquer and causing unsightly patches. From the observation room the lacquered or finished cans are moved to the store and thence as, required, to the labelling and despatching room.

CHAPTER VI.

Defects.

131. It is obvious from the above pages and from experience that cans and canned goods are liable to many troubles, whether from original defects in the can body before packing, or from leaks after packing and sealing, or from mere distortions of the containers, or from originally bad or inferior contents, or from bad preparation and improper treatment of contents and can, or from bacterial or chemical action within the can. This, however, is not to say that canned goods are more dangerous or more to be suspected than ordinary foods; on the contrary, they are—in India at all events—*much less so*; canned goods are often unjustly blamed when the blame should be given to other articles of diet consumed at the same time, or to dirty cooking utensils or practices, or to slightly tainted 'fresh' food (fish and shell-fish specially); canned goods display their defects and are consequently liable to blame when it is the *concealed* defects of other foods that are the true cause of illness or discomfort. Moreover, just because of these difficulties, special care and knowledge are given to their preparation and marketing, so that canned goods as found on the market are usually *the safest of goods* having been carefully selected, handled, *sterilised*, and then protected by good containers from contamination or damage.

132. Briefly it should be said that if a manufacturer is honest and does not 'work over' *deteriorated or spoiled* cans (e.g., by venting and reprocessing, which is a most dangerous and fraudulent trick based on absolute greed and carelessness of results) but destroys the contents of all 'blown' tins, and if consumers will observe the simple precaution of rejecting or throwing away all tins which really are 'swells' ('blown'), there is not only no risk in consuming canned goods but such goods are positively far safer than much of the food supplied to consumers. All canned goods have been absolutely sterilised during the operations of canning, and if they subsequently go wrong they positively and unmistakably advertise the fact by the condition of the container or of the contents. Cases are known to the writer where consumers fell ill not because the canned goods (made abroad, not in India) did not advertise the fact that they had gone wrong but that the

consumer chose to neglect the suspicions caused by the condition of the canned contents. On the other hand (see below *s.v.* 'springers,' paragraphs 136—139) the consumer should be sure that the can is really a 'swell' ('blown' by reason of decomposition) and not merely a slightly distorted one or 'springer.'

133. *Defects in empty cans before packing.*—These mainly arise from defective soldering or seaming of the can bodies and bottoms. In U.S.A. practice, cans made by can-making factories whose sole or main business is the production of empties for the use of the canning factories, have arrived at such perfection, especially in the nearly solderless or sanitary lock-seam cans, that 2 per mille is the maximum allowed for defective cans and the manufacturer makes good any losses due to any excess over such proportion. But the cans mostly in use and of that make are the cylindrical cans so well known as containers of salmon, soups, preserved fruits, vegetables, etc., and not only are these easy to make by automatic and very perfect machines but they can be and are regularly tested for complete air-tightness before leaving the can-making factory. There are various devices for the purpose, but compressed air is the more general and simple method, by which cans are submitted, under water, to jets of compressed air which instantly issues in a stream of bubbles from the smallest aperture. Water under pressure is also but less commonly used. But owing to the perfection of modern lock-seam plant the testing of empties is of less importance than formerly.

134. In India some such device is advisable, for experience, as gained by compelling solderers to place their marks on can bodies when making empties, shows that leaks are nearly as common in making the cans as in sealing them after packing. It is however difficult to test such cans as shallow, rectangular quarters. A shallow flat bottomed pan of water with a jet in the centre conveying compressed air admitted by a conveniently placed tap worked by hand or foot to an empty can held firmly below the water, is perfectly feasible, and might save its cost in a year or two from the diminution of leaks and consequent spoils.

This source of trouble is of course absent altogether in 'solid drawn' cans as made (quarters and ovals) in the Beypore factory, since there is no joint or seam whatever in the empty bodies.

135. *Defects from leaks after packing and sealing.*—These have been sufficiently dealt with elsewhere in describing the several

processes. Briefly it is primarily a matter of good sealing whether by solder or by double seaming, and of good testing and exhausting, with, if pressure steam is used in processing, additional precautions to prevent undue strain on the joints, especially those made by soldering.

136. *Defects from mere distortions*; '*springers.*'—As shown above (*s.v.* 'exhausting' and 'processing') cans are often liable to slight and occasionally to serious distortion from mechanical (air and steam pressure) causes. When the tin is very thin and unsuitable to the character of the cans—as happened frequently during the war when tin plate was almost unprocurable and unsuitable qualities had to be used—this defect was very common; many of the plates were found buckled even when in the flat, and this itself gave rise to buckled tops and bottoms; or the thin plate of cans processed under high temperature and pressure, buckled severely under the pressure and became permanently distorted; or the exhaustion was too complete and the thin plate buckled by reason of the high internal vacuum. These distortions are purely mechanical and have nothing to do with the condition of the contents; but owing to the possibility of their rejection by the consumer who mistakes these 'springers' for 'swells,' it is necessary to avoid them by using plate suitable to the sizes and shapes of the cans, and not to issue, even at the cost of some loss, such 'springers' as are *reasonably* liable to be mistaken for 'swells'.

137. Another and frequent source of springers is imperfect or imperfectly set dies, or uneven pressure or imperfect buffers in the presses which cut the tops and bottoms; this of course is more frequent in dies of large superficial area, which require most careful setting, otherwise the tops and bottoms will be so distorted, usually at corners diagonally opposite, that they will not lie flat on a flat surface. This distortion is a ready cause of springers; when the can is put together and forcibly secured in position by the solderer with his ratière, the soldered, distorted plate at once strives to reassume a distorted condition; hence a tendency to buckling which may be immediate or developed under subsequent pressure; in any case the attempt to resume its distorted form causes a heavy strain on the joints and, especially in the case of soldered tins, is a fruitful cause of leaks. Hence much attention is required to plate and to machines.

138. A 'swell' is quite unmistakable; since it is caused by internal decomposition with *the production of large quantities of gas*, the whole can swells by the severe internal pressure so that *both top and bottom* become convex and cannot be pressed inward by any ordinary pressure; they will often burst rather than yield to external pressure; in many cans the seams, especially if soldered, give way slightly so that the contents ooze out. If such cans are opened there is a strong escape of foul-smelling gas, and the contents are seen to be mushy and unmistakably tainted.

But the 'springer' or 'flipper' shows no such conditions; in nearly every case it is only *one* side (top or bottom) that shows any convexity; this convexity is, moreover, often only partial, extending over part of the affected plate, and is generally comparatively slight. This fact of itself shows that the convexity is not due to internal gas pressure, for in such case (internal gas pressure) the convexity must necessarily show itself *on both plates equally* since the gas pressure is necessarily equal over the whole area of the can; moreover gas pressure could not render *part* of one side convex and leave the other part normal. Finally, these 'springers' can readily be pressed inward by the mere pressure of a finger, and may or may not resume their apparent convexity; this is conclusive of the fact that the contents have not decomposed but are perfectly sound. This is well known to canners and has been tested in very numerous cases in the Government Cannery and the contents personally tasted and consumed.

139. Hence it is unfair to canneries that 'springers' should be treated as though 'swells'. Nevertheless the wise canner will

(1) take every precaution to prevent these springers by the use of suitable and good plate, by careful stamping of the tops and bottoms in a *properly adjusted* press, by proper exhaustion and processing, and by care in releasing processed cans from pressure;

(2) he will refuse to issue any cans which are so *markedly* distorted that the public are likely to mistake springers for swells and thus cause the canner loss of reputation and consequently of custom.

140. *Originally bad contents.*—This has been dealt with above. No canner who regards the consumer or himself will be other than absolutely careful in selecting and using perfectly sound canning material; he will suffer any loss rather than pack, for instance,

fish otherwise than in perfectly sound condition ; indeed he would otherwise soon have to cease canning from want of business or from magisterial action.

141. But there are other causes for originally bad or poor contents against which the canner must be on the watch. Fish may be perfectly good as regards freedom from taint, but be such as to give results unacceptable to the consumer ; e.g., fish may be 'spent' (exhausted after spawning), or out of season, or be very thin so as to be little but scales and bones, or large but utterly tasteless. For instance, sardines *may* be not worth canning after February or March, when they are generally small, lean, and without flavour ; or again certain classes of Indian sardines such as the chálamathi (Clupea fimbriata) are always of poor quality, and are not only bony but have especially hard bones ; these should never be canned for high class goods. Certain large fish, moreover, do not seem to can properly, developing a bitter flavour ; this however may be due to a wrong recipe or method and not to improper material.

142. Or again the fish may be good but the oil may be insufficient especially with steamed sardines, or of wrong quality, or rancid, or even may have been so 'refined' as to lose its best characteristics. Coconut oil will spoil any can, and other oils, though good cooking oils, are quite impossible for canning unless for particular classes of consumer. Rancidity is unfortunately common in India where the original preparation of oil is generally defective and productive of rancidity ; fortunately a laboratory is not essential for testing such oil, since the experienced canner can detect rancidity by the taste and by the way in which it affects the throat ; moreover, acidity can be detected and measured by simple means.

Spices again may be cheap but flavourless, or improper spices may be used ; ordinarily speaking, for canning other than fish paste very little spice is used and that mainly for sardines or marinaled fish.

143. *Bad preparation and treatment of the can and its contents.*— This has been dealt with *passim*, and involves the whole operations of canning from the moment of catching to the close of processing ; bad treatment in the boats, improper purchase and use of badly treated fish, wrong brining perhaps in dirty or weak brine, bad drying, careless frying in bad oil, excessive dryage by steaming

or frying, negligent and ugly, irregular packing, insufficient or excessive exhaustion and processing; to which may be added rusty and coarsely soldered cans and ugly or dirty labels.

144. *Bacterial or chemical action within the can.*—This malady refers to cans that have been well packed with good material and with apparently correct results as regards hermetical sealing, and yet go bad mysteriously, sometimes quickly but more often after a considerable period, as in the store room. These are probably due to some occult bacterial or chemical action which cannot be detected without the aid of the bacteriologist and chemist, and in India this is seldom available; the canning bacteriologist is somewhat of a specialist, and, if available, the facilities for submitting cans and obtaining a useful opinion are few. Defects such as the discoloration of fish, especially prawns, may be due not to bad cannery treatment, but to inherent causes such as the constituents of the fish (e.g., possibly sulphur) affecting or affected by the material of the container. This is dealt with elsewhere; see 'container' and 'prawns.'

CHAPTER VII.

THE CANNING OF SPECIFIC FISH.

145. It remain to describe the canning of particular fish and to mention recipes ordinary, special, or novel.

146. *Sardines.*—The fish most generally canned is perhaps the sardine, whether the true sardine (young pilchard) of the French and Portuguese coasts, or the young herring of the United States of America (specially in Maine), or the sprat and brisling of Norway (largely brought from English coasts), or the Indian sardine, or that of Japan. They are thus all of the clupeid family, but their character differs considerably; e.g., the true sardine (Clupea pilchardus) is an immature pilchard, while the Clupea longiceps or Indian West Coast 'oil sardine' or 'Nalla mathi' is, when best fitted for canning, a mature fish; the Clupea fimbriata (chála-mathi) is usually too hard, lean, and bony, for good canning. The difference is important, for in the mature Clupea longiceps the bones and scales are more strongly developed than in the true sardine or young pilchard, so that the Indian goods have certain initial disadvantages such as the hardness of the bones and the surface plating of scales.

147. The sardine is generally canned in oil but also to a great extent in various sauces, tomato, mustard, curry, etc.; sometimes they are canned in butter and are boned; sometimes (Beypore) they are canned plain, without oil or spices except black pepper. The main difference in all these rests in the condiments.

148. On the Indian coast the fish are caught either by the odam (paithu) net or by the gill net; the former is more advantageous in that it may obtain large quantities at a haul and brings the fish alive into the boat, but has the disadvantage of catching large and small alike; the gill net catches fish of uniform size, viz., those that can just get their heads and gills into the meshes, but makes comparatively small catches under ordinary circumstances and kills the fish in catching them. The fish are sometimes caught within a few hundred yards of the shore, but may be several miles out; it is advisable therefore to have fast canoes in attendance as carriers which can buy the fish from the canoes immediately on capture and bring them rapidly to shore, for the

fishing canoes will remain at sea as long as they have an insufficient catch or hopes of more ; hence the cannery is apt to lose the best part of the working day and the freshest fish unless it has one or two carriers, which, however, need not ordinarily be motor carriers, but merely light, well manned canoes. It is, however, possible to fit light canoes with small motors which can be used when necessary ; motors are made which are readily detachable and can therefore be unshipped when not needed or can be transferred to other boats. Another reason for employing carriers is that the fish are thrown into the bottom of the fishing canoe to die slowly of suffocation, and are bruised by the movements of the crew and by the weight of other catches thrown on them. Now since the sardine is a delicate fish and since the struggles of slow suffocation cause a tendency to rapid degradation of the tissues and consequent early taint, and since the lower layers of fish are often bruised and soft, it is frequently necessary, in the absence of special carriers, to buy only the upper layers ; hence not only delay and loss of good working hours, but a shortage of fish.

149. The carriers should be so arranged that the fish shall be protected from injury en route, e.g., by having proper boxes or baskets to hold the fish ; also protection from sun and, if possible, a little ice so as to keep the temperature below 60° F. ; this will keep them good for some hours. It is for consideration whether, if ice is impossible or the shore distant, the carrier should not be big enough to have a central well in which live sardines can be placed, with communication, by gauze covered holes, with the sea ; if the fish are dead the sea communication may be closed and the fish kept in a bath of 5 per cent salt water (sea water slightly strengthened with salt) with a small quantity of boric acid or of some other innocuous fish preservative such as Keeps, Arcticanus, Preservaline (American), Neutraline (French ; sodium sulphite, used in America for blanching fruit and also for preservation of goods intended for canning), sodium hypochlorite, etc., in order to inhibit (delay) putrefaction ; it is better to prevent putrefaction even by preservatives when innocuous, than to permit the chance of it. It is also possible to place live fish in a separate live car which may be towed behind the canoe carrier.

150. Assuming that the fish are brought fresh to the cannery they are at once beheaded and gutted by a gang of women and

children, thoroughly washed in pure (sea) water by being placed in a basket which is then agitated in a vat, and thence removed to the bath of saturated brine where they remain from 20 to 30 minutes according to their size and the judgment of the maistry. It is well, especially when fish have been caught by the odam net, large and small together, that they should be sorted so that the brining, drying, etc., shall be suited to the several sizes; it is obvious that the large ones require more salting and more drying and more frying than the small ones; moreover there is less trouble in packing if the fish are graded. Some French canners recommended an addition of 'Neutraline' (which is simply sodium sulphite) to this bath, and there can be no reasonable objection in the Indian climate; better a minute amount of innocuous preservative than the toxins of incipient putrefaction. This precaution has not, however, been used at Beypore. But under conditions which necessitate delay in packing, very hot weather, etc., the method is harmless and even desirable. Sodium hypochlorite would seem preferable, as it turns to common salt in acting on organic matter. Some canners throw the fish into the brine bath (with or without the above preservative) immediately on arrival at the cannery and before gutting; this has the advantage of tending to keep off the progress of taint during the subsequent work of gutting, and also makes the fish firmer to handle. But with Indian fish a longer time would then have to be given for brining, since the salt penetrates with more difficulty into a fish undecapitated and gutted and provided with scale armour; when beheaded and gutted salt penetrates rapidly. Moreover if the fish have been in a bath of weak 5 per cent brine and preservative while in the boat, brining before gutting is unnecessary.

151. Thence they are thrown on to tables and rapidly ranged in the grilles, which are then placed (either hung on scaffolds or supported on 'flakes') on the drying grounds or in a drying room heated by currents of air provided by a fan or in other ways; this operation needs care, since over-drying in the sun blanches the fish and spoils their appearance; it is only necessary to drive off the external moisture resulting from the brining and thus reduce the time and cost of the frying.

152. When sufficiently dried the grilles are taken to the frying room and placed on a rack closed to the frier. This frying operation is most important and somewhat costly. The object is to firm

the fish by cooking it at a temperature above that of boiling water, so that the moisture (which in fish amounts to 70 per cent of the weight of the whole fish) of the tissues may be partly driven off as steam; this not only sterilises the fish but firms and shrinks the tissues so that the fish can be conveniently handled and packed, and will also bear processing and transport without breaking up and becoming 'mushy' in the cans. In this operation a certain amount of oil penetrates the fish and to that extent flavours them; hence the necessity for good oil even in frying. It is obvious however, especially with such small fish, that the rapid drying effected by oil frying may drive out so much moisture that the fish will shrink and dry excessively; this must be guarded against, for a dry sardine is a spoilt sardine. Ordinarily a minute or so at a temperature 270° to 300° F. is sufficient; the fish are sufficiently done when they begin to rise to the surface of this oil, this fact resulting from the drying out of moisture and thus rendering the fish lighter.

153. It is also obvious that both sterilisation and the driving off of moisture can equally be effected in other ways, e.g., by the baking in an oven or by steaming with 'dry' steam. These methods have the advantages of speed and cheapness but the French canners claim that the best goods are not produced in this way, since the fish do not absorb oil. On the other hand these methods do away with the ill effect of bad or scorched oil as is often found in the pans after a number of grilles have been fried, and the fish can easily be given extra oil when packing. At Beypore steaming has been successfully resorted to, but the experiments require further investigation and new methods. See paragraphs 59—63 and 94—98 supra *s.v.* 'frying.' It is however certain that steamed sardines require more oil in packing than sardines fried in oil for the reason given by the French canners, viz., that sardines fried in oil necessarily absorb oil. Moreover great care must be taken not to steam the fish too long, as this unduly dries and hardens the flesh.

154. The fish after the surplus oil has been drained off are emptied from the grilles on to tables which are preferably covered with zinc, slate, glass, etc., for purposes of cleanliness. Here they are packed into cans, usually 'quarters.' The cans are thoroughly cleaned and a clove, two black peppers, and a piece of bay leaf (a sprig of thyme is often added by the French) are put in ready for packing; some canners add the required oil before the fish are

packed; others afterwards. The packing should in any case be such that while the fish are closely packed there is room for the full amount of oil; it is a grave mistake to be over-sparing in oil, since the fish, unless very fat, absorb a great deal of oil, especially if baked or steamed instead of being fried, and a can almost devoid of oil is not attractive, nor do the spices sufficiently part with their flavour in a dry tin. The top layer should be of selected fish and very neatly packed so that when opened the fish may present an attractive appearance and please the consumer; an irregular, ragged appearance repels. In key-opening tins the can is only opened at the top: in keyless tins it is well to put a mark indicating the top so that they may not be opened wrongly.

155. The oil as explained above (paragraphs 80--86) is a very difficult subject; in the highest classes of French goods olive oil is always used, but it is to be remembered that much 'olive oil' contains groundnut (arachis) oil; in other countries, e.g., the United States of America, cotton seed oil is frankly (and by law) the standard packing oil. Here in India canners are at present almost confined to refined groundnut oil, but a mixture of the *highest class* sardine oil is not only not objectionable but masks the groundnut flavour and enriches the fish from which class indeed it has been prepared. Refined cotton seed oil of the best class is better for Indian packing than any other obtainable oil, but may be mixed with the groundnut and sardine oil; at present it is hardly, if at all, obtainable.

156. The cans most used are rectangular 'quarters,' i.e., normally quarter of a kilogram (2·2 lb.) or nearly 9 oz. of which about 2½ oz. are the weight of the soldered tin; hence nearly 6½ oz. fish in the full sized quarter of 4½″ × 3″ × 1″. But both in France and elsewhere the quarters often weigh far less and give only 4 or 5 oz. of fish in a can ⅝″ to ¾″ depth. In Beypore the nett weight of fish packed averages 7 oz. which is the standard. In soldering these quarters the use of the ratière is indispensable; this forces the four sides close up to the cover, so that a minimum of solder is needed and none can get into the can.

157. If the sardines are received so late that they cannot be closed or processed the same day, it is quite safe, *after* sterilisation and pre-cooking by frying or steaming, to pack them into the cans with oil or to place them in a cool place till next morning, but in either plan they should be entirely covered with oil. This not only preserves but enriches them.

158. The operations of testing, exhausting, and processing, have been fully described above (paragraphs 101—129). But sardines in oil need not ordinarily be exhausted

(1) if thoroughly full of oil;

(2) if the cans are so dished that air is practically excluded. The omission of exhausting greatly saves time and labour which balances the cost of any excess of oil so used. But 'plain' sardines packed without oil must be exhausted, since there is considerable air in such cans.

159. The time of processing varies according to the size of cans and the method; in open boiling pans at 212° F. quarters usually get not less than 1½ hours; in steam pressure kettles the time is about 30 to 35 minutes. Halves (weight about 1 lb.) get about 2 hours and 45 minutes respectively.

160. It is possible to can sardines in oil in very large tins, e.g., gallon or 4-gallon kerosine tins in such a way that when opened they will keep good for some days so that a retailer can sell sardines in oil to his customers by the pound or less. At Beypore the sardines were brined for a considerably longer time than usual, viz., for an hour or two (taking care that brine is kept at saturation point), and were then treated as usual right through to processing, which of course must be long in proportion to the size of the cans. These cans were afterwards opened and left exposed to the air; none went bad though open for many days, but in the warm damp climate mould appeared on the surface. Special care must be taken with the larger tins; the plate must be extra stout, and, if kerosine tins, the seams must be, or be made, perfectly air tight by floating with solder. The tins should be packed closely and filled with the oil so as to exclude air as much as possible; otherwise when exhausted, as is necessary, and then processed, the tins will appear as though battered and may collapse. For if there is much air before exhausting, the operation of exhausting will drive out the air leaving only steam; when, after processing, the steam condenses, the internal vacuum will be considerable, and the tin will fall in at many places. Cylindrical cans of 8 lb. and upwards may usefully be packed in this way, and if lock-seamed and solder-floated will, if properly treated in packing and exhausting, retain a good appearance.

161. *Plain sardines.*—These are greatly esteemed by those who wish for the natural flavour of the fish. This method should only

be used for the large fat sardines in the best of condition, as found in the West Coast between (roughly) August and January after the high feeding provided by the south-west monsoon. These fish are large, 8 to 12 to the quarter can, of delicate flavour, and so fat that though canned without oil, a table-spoonful of oil may be found in the can when opened after processing. All the usual operations including frying, are gone through; the only difference is that neither oil nor spices—except black pepper—are packed with the fish.

162. *Sardines in curry.*—This method is largely in use in Beypore as a substitute for sardines in mustard sauce (much used in America) and consonant with Indian tastes. The particular mixture is left to the canner's choice, but oil must be freely added, according to the character of the fish, and the mixture should be placed between the layers.

163. *Sardines in mustard sauce.*—This is a favourite American method; the particular recipe for the sauce must be left to the canner, but it should be thin, like catsup (ketchup) and consist of good ground mustard, cloves, turmeric, chillies, bay leaf, etc., ground together and mixed with (tarragon) vinegar.

164. *Sardines in tomato sauce.*—This is a favourite recipe in America and is also followed in India. The sauce is used instead of oil though a small quantity, say, 1 to 2 oz. of fine pure oil or butter per pound or pint of sauce, may be added.

A good recipe for the sauce is as follows:—

Ten pounds fresh tomato, 2 oz. of salt, 5 oz. onions, a few cloves and bay leaves; boil for two hours in an enamelled pan and strain through a fine sieve. This may be used at once, but if prepared when tomatos are abundant or not at once required, it may be sealed air tight in large tins, and processed at about 220° F. for from 20 to 30 minutes for pints and quarts respectively. Being a fluid, the processing is more rapid than with solids or semi-solids, owing to the setting up of convection currents. If a temperature of 220° F. is not possible (owing to want of pressure steam retorts) a longer processing at boiling temperature will suffice.

Other recipes are available in various text-books.

165. All canned sardines except 'plain sardines' are the better for keeping in stock for some months since the various

components and their flavours have time to commingle and mature into the single delicate flavour known to consumers: a newly made can of good material is edible but not desirable since the various flavours are separately distinguishable and crude. No French canner of repute sells his goods under some months or a year. 'Plain sardines' however are at their best at once.

166. The season for sardines in good condition is short on the West Coast, usually from August to February; after February they are apt to be lean, out of condition, and small. They are still cannable, but are not first class goods, and require more oil than in the proper season. During the monsoon, from 1st June to the end of August, sardine canning is practically at a standstill.

167. *Mackerel.*—This fish is not a favourite for canning in Western countries partly because it is too large to be canned whole, partly because it is a fish which rapidly taints, so much so that it is, or was, called the 'Sunday Fish' (piscis dominicalis) because by old English law it was, on account of its tendency to taint, the only fish allowed to be sold on Sunday. On the Madras Presidency coasts, however, this fish appears—irregularly—in vast shoals inshore, and is but a small fish ordinarily of 3 or 4 oz.; hence as regards size it can be readily canned. As a matter of fact however, though sardines were for many years canned by a French canner at Mahé, no attempt was made to can mackerel (prawns, oysters, etc.) until the Government Canneries at Calicut and Beypore successfully experimented in 1912 and 1913, since which time this fish has been regularly canned and is deemed by the public at least to equal any other canned fish, and no stock can be kept in hand when the public are aware that these fish are available. But it is still a tricky fish to handle and the canner must be most careful in his selection of fresh fish; for some unknown reason these fish, even if processed at 240° F., are apt to spoil in the cans. So long, however, as cans retain the ordinary characteristics (concavity, etc.), of sound cans and the fish are firm and clean, there is no more risk than with sardines. Pressure processing is however desirable if not necessary, with mackerel; it is better to process fish in general, except perhaps sardines in oil, well *above* boiling point (212° F.). Mackerel are treated very much as sardines up to the drying operation inclusive, but being larger and more apt to taint, the brining should be longer, especially as these fish are usually canned plain, just like 'fresh herring' which

they resemble when completed. A harmless preservative in the brine is also more important than with sardines.

168. *Frying.*—This may or may not be practised; if there is likely to be some delay in closing and processing fish, it is necessary to fry them in view to their sterilisation; they are then placed out of danger and may be kept covered with oil even till next day. But for 'plain mackerel' frying is not necessary and is apt to dry the fish too much; mackerel are by nature a somewhat dry fish so that care must be taken. If at all over-dried they should be packed in oil or curry or marinated; all fried mackerel are the better for such packing.

169. *Packing.*—The rectangular cans used at Beypore (see supra paragraphs 32—39 *s.v.* 'cans') are too small for mackerel which are consequently packed in flat cylindrical cans holding 12 oz. nett of fish; these are easy to pack, close, exhaust, and process; the packed cans weigh 1 lb. to 17 oz. They are also packed in double sized tins holding 24 to 26 oz. nett of fish; these are very good value. 'Plain mackerel' are packed with a couple of cloves and a few black peppers, but no other spice.

Oval tins are usually used for herring and are advisable for mackerel also; these are best made of the solderless pattern and the Beypore cannery has the necessary dies and chucks for somewhat small ovals, but these have not yet been used.

170. *Closing, etc.*—These cylindrical tins are placed centrally on small turn tables and the solderers seem to be more successful in closing them than the rectangular tins.

Since the cans of plain mackerel necessarily contain much air (and steam when processed), it is absolutely necessary to exhaust them thoroughly, so that tops and bottoms may be concave. Processing should be at temperatures above 212° F.; at Beypore 240° is usual and the period about 45 minutes; probably 1¾ to 2 hours at 212° will suffice, since the heat is more rapidly communicated to the fish in these cylindrical tins which are not very closely packed and, with the plain, non-fried mackerel, contain a good deal of moisture (like plain herrings) as is seen when the cans are opened.

171. *Mackerel in oil.*—These are treated just like sardines in oil, but must not be fried too long or at too high a temperature, otherwise the flesh will become unduly dry and hard.

In packing these fish it is advisable to use rectangular or oval tins, both of which can be packed much more closely than cylindrical cans and therefore require less packing oil which would be very expensive in a can not closely packed with fish· This mode of packing in oil has not yet been used at Beypore, but may now be adopted as soon as good oil is procurable and cheap.

172. *Marinated mackerel.*—This product, well known in Europe and imitated in Cornwall with pilchards, is excellent but requires several precautions. Marination is simply the packing of the fish in a spiced vinegar; the recipes are very varied according to the taste of the canner and his market. A spiced vinegar may consist of vinegar 1 gallon, mace ¼ oz., nutmeg 11/16 oz., black pepper 1 oz. salt 2 oz., cinnamon 1 oz., cloves ¾ oz.; these should be mixed and left for 24 hours and then boiled for five minutes and strained the spices may be put in a muslin bag. Water should be added when used. A 'Court Bouillon' which is a milder preparation, may consist of water with vinegar (about one-fourth of the water), onions, cloves, garlic, pepper, salt, parsley, and thyme, all boiled together for an hour and strained. Or the fish may be canned with a slice of lime or lemon, a slice or two of onion, a clove and a little parsley, and the can filled with vinegar and water in equal proportions. Another recipe is water 100 lb., strong vinegar 10 lb., cloves 1/2 lb., bay leaves 1/2 oz., sliced onions 2 lb., salt 3 lb., black pepper 1/2 lb. Soak the spices in the vinegar for 48 hours; then boil the water, salt and onion together, add the vinegar and spices and boil together for a minute and strain. A recipe for marinated herring which may be followed for mackerel is as follows. Behead, gut and wash the fish, brine for 30 or 40 minutes, dry off the external moisture and pack in convenient (oblong or oval) boxes with onion, garlic, lemon or lime, thyme, bay leaf, pepper, pimento (allspice), cloves, etc., according to taste; solder, and then through a hole left for the purpose, add vinegar diluted with water, tip, exhaust and process. The reason for introducing vinegar and water *after* soldering is that is almost impossible to solder the tops or caps on to a can which is *full* of any watery fluid or fluid other than oil, owing to the formation by the hot soldering tool of steam which forces its way through the melted solder and prevents hermetical seaming. There is however no difficulty in mere tipping. Of course no difficulty exists in hermetically closing *solderless* cans by double seaming.

173. Many other recipes are of course possible at the discretion or ingenuity of the canner. Another method is to proceed as before up to drying inclusive; then fry the fish in oil, or steam and bake them, and pack them with a marinade of tarragon vinegar mixed with good mustard or with tomato sauce, etc.

174. A favourite method of putting up mackerel in the United States was to pack salted mackerel; in this case canning is practised rather as an assistance to marketing than to preserving. Good well salted mackerel are washed, their heads and tails removed, and packed in large cans of 3 lb. and upwards, some fine salt being sprinkled among the fish as they are packed. After the top has been soldered on, a puncture is made, strong brine is inserted and the can then tipped. It does not appear that these mackerel are processed, but this might be done at ordinary boiling temperature (212° F.).

175. *No fish*—mackerel or other—*prepared with vinegar* should be packed otherwise than in cans enamelled or double lacquered inside, since vinegar acts rapidly upon the metal. These products should be sold off as soon as prepared, in order to prevent any risk of such corrosion.

176. *Large fish*.—These may be seer *(Cybium commersonii)* pomfret *(Stromateus niger* and *argenteus)*, bámin or Indian salmon *(Polynemus)*, etc. They must be cut in slices by a guillotine slicer, the slices being somewhat thicker than the depth of the tin which is usually cylindrical or oval.; or they may be cut into chunks like salmon and packed in cylindrical tall tins. The slices shrink somewhat in brining, drying, etc.; hence the need for a slight extra thickness. In brining it is to be remembered that salt is very rapidly absorbed by cut tissues; hence a slice of fish presenting two cut surfaces, brines with great rapidity, and requires only a few minutes—according to the fish and the thickness of the slices—in saturated brine. In drying also the heat should be moderate, to keep the surfaces from too rapid hardening which prevents internal drying. In frying again the oil should be of moderate temperature to permit of a thorough sterilization and firming of the inner tissues especially those near the bone.

177. *Plain packing*.—In this case nothing is needed except salting, drying, and packing without any frying, spices, or oil; the products are quite good and may be used in lieu of fresh fish or for made dishes, curries, moli, etc. Salmon as ordinarily packed is

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representative of this class, which has been successful with seer and pomfret. It is found that black pomfret, packed with the skin, gives a natural jelly at Nilgiri temperatures; in order to ensure this jelly in the low country a little isinglass, gelatine, or agar-agar may be used. In various text books it is recommended to jell the contents of any can of plain sliced fish by the use of these agents.

178. *Packing in oil.*—The Mediterranean tunny is perhaps the representative of this class of packing; the method has been successfully tried with seer, pomfret, etc., in the Beypore Cannery, but the individual canner can invent and try various recipes.

179. If possible the fresh seer, pomfret, bámin, etc., should be beheaded, gutted, and washed in salt water while *on the canoes;* this can be done by a slight organization of supplies. The French canner (in France) whose process is chiefly followed below, insists on an innocuous preservative such as neutraline (sodium sulphite) or boric acid being added to the salt water bath while *in the boats;* this was similarly shown to be useful by experiments in the United States of America (see " Preservation and Curing of Fish," Madras Fisheries Bulletin). The fish need not be soaked or kept in such a bath, but thoroughly cleaned and bathed for a few minutes; the operation is mainly detergent.

180. The fish when received are beheaded, gutted and washed as above if not already so treated in the boats; then cut into slices with a guillotine or other machine slicer, and placed in saturated brine for such time as is desirable. It may be noted that the time given for Mediterranean practice is 20 minutes or longer; this coupled with 20 minutes subsequent simmering (see immediately below) would seem to render cut slices unduly saline; doubtless it is a matter for the canner to decide, because the subsequent drying process is slow and may continue for days; in Beypore practice this considerable period in saturated brine is not given for cut slices, but they have always been canned on the same day. If however conditions (e.g., lateness of hour, press of work) show that the fish must stand over (see below) till next day, the brining (with a little preservative added) should be longer than if the fish are canned at once. Thence, in French practice, the slices are removed into a shallow cooking vessel with similar brine and allowed to simmer—*not* boil—for about 20 minutes; if allowed to boil the slices become hard and dry. It is not clear why the fish, after cleaning should not be placed at once in this bath of brine and

heated until sufficiently pre-cooked and salted, care being taken to skim off all impurities. The slices are then removed by hand, placed carefully—for they are now fragile—on trays and dried, if possible in the open air; the drying should be carried to such extent as to drive off all external moisture and enough internal moisture to render the slices firm and to avoid undue fluid in the cans after processing. One text-book states that in the Mediterranean the drying may take several days; this is certainly not required in the tropics. Since, however the slices are thick, it is well to dry slowly rather than rapidly, in the warm air rather than in full sun. The slices are then picked over to remove any impurities, bones, black skin, etc., and then packed, care being taken to fill the cans full, since the slices shrink somewhat in processing. The cans (in French practice) are then filled with oil, and spices are given as for sardines, but other condiments and herbs such as red tomato, tarragon, truffles, mushrooms, etc., may be added for very high class goods. It is specially noted that, if desired by reason of pressure of work, it is easy to keep these fish till at least next day by simply placing the slices in larger tins or boxes and covering them with oil, *provided* that they have been well brined and pre-cooked as above, especially if the brine has been given a small addition of preservative such as neutraline. With slight exceptions the above and the following process *(à la bonne femme)* have been more or less followed in packing slices of large fish in Beypore.

181. *À la bonne femme.*—This method follows the above up to drying inclusive, but the fish are then fried in oil like sardines, care being taken not to over-fry the fish which in such case not only shrivel but become hard and dry. Instead of oil and spices a sauce is added composed of butter and vinegar with salt, pepper, nutmeg, parsley, onions, and a little garlic, care being taken not to overspice the sauce but merely to flavour it. The butter is melted in an enamelled vessel, a little flour added to thicken it, and the spices and vinegar diluted with water are then added and heated with it: the mixture, after cooking, is passed through a sieve. In the best recipes white wine with a proportion of vinegar is the fluid element, but as one author says, the wine is a luxury, and the product is just as good without it.

182. *Salmon.*—Though salmon are not found in India it may be of interest briefly to describe salmon canning as practised in America.

A salmon cannery on the Pacific Coast (e.g., at Puget Sound, Washington, United States of America) may have a capacity for dealing with 10,000 cases (each of 48 one-pound or 24 two-pound cans) per day, and with such speed that a salmon alive one minute may, within 20 minutes, have been perfectly packed in a closed can ready for processing, so that there is no possible chance for taint. The premises are absolutely clean, as are also the operatives; in one known case the can-filling attendants are young women compelled to wear clean uniforms, and washing gloves changed at least twice a day; this is mentioned as suggestive of the thorough cleanliness observed in all operations. The fish received alive from the boats are at once beheaded, gutted, and well scrubbed with brushes in running water; they are then sliced, usually by machines, into convenient portions, and are then filled into the cans, a slip of tin being placed on the top so as to prevent the pin hole in the cover from being choked with fish during the soldering process. The cans are then closed, the caps, which have a pin hole in the centre, being pressed on and crimped tight by automatic machines; from the capper the cans roll first through a bath where acid is smeared on the crimped edge, thence through a trough of melted solder which adheres to the parts that have received the acid flux, and finally through a cooling trough to set the solder. At this point the pin-hole in the cover, which was left to allow of the escape of the steam and air during the hot soldering process, is quickly closed by a drop of solder, and the can then passes to the testing bath of hot water, immersion in which at once reveals any defect in soldering since the contained air heated by the bath issues as a stream of bubbles; defective tins are at once removed and resoldered at the leak. The cans found to be hermetically closed are now ready for the first cooking called "exhausting"; they are arranged on trays in crates or cars which are lowered by cranes if the kettles are vertical or run in on rails into the more usual horizontal retorts; here they are processed, usually at about 225° F., or 5 lb. pressure, for half an hour. An open bath is sometimes substituted for the process, as the object is chiefly to heat up the cans so as to permit of the subsequent exhaustion of the air by venting and reclosing. On removal the cans are rapidly vented to allow of the escape of hot air and steam, by being struck with a mallet having a sharp point in the centre; this vent, through which steam, air, and a little fluid issue, is sealed

by a second operative as soon as opened, so that the can is now practically exhausted of air.

The exhausted cans are now finally processed at 15 lb. pressure, i.e., 250 F., the process continuing for about 1 hour in the case of 1 lb. cans. The cans are subsequently tested either by striking them with a piece of iron like a spike nail, or by striking them against an anvil; the sound given by a perfect can and that of one with the slightest perforation are readily distinguishable by a trained ear. In Japan the completed tins were kept for a week or two in a warm store, by which time any imperfect can discloses itself. This concludes all essential operations and it will be noticed that nothing but wholesome fresh fish has been placed in the cans, and that preservation is effected by sterilization and hermetical closure. It remains merely to clean, varnish, and decorate the cans with some suitable and attractive label.

183. *Prawns.* (Called 'shrimp' in the United States of America).—These are easy to can but not so easy to preserve in good condition when canned, as may be judged from the fact that the first American canner of prawns began experiments in 1867 but did not meet with success till 1875, an excellent commentary on canning difficulties and on the arm-chair criticisms of canning experiments and results; compare the similar experience in the canning of sardines in the United States of America when first introduced by their canners

184. The method adopted in the Government Cannery (where prawns were first canned in India, since they were never previously canned at Mahé) is as follows, and is based on the method of semi-drying prawns at Tanur.

The fish must of course be fresh and if possible alive when brought to the cannery; though Indian—non-European—taste seems ordinarily to prefer the 'white' variety they do not can so well as the 'red' ones, being less tasty, besides presenting a pallid, ugly appearance in the tins as contrasted with the brilliance of red prawns. They are at once dipped for a minute or so in *boiling* water, the precaution being taken of dipping only small quantities of prawns at a time; for instance, a large iron boiler about 48 inches long, 20 inches wide, and 14 inches deep, is set over a furnace burning wood and provided with a small chimney; into this are poured about 40 gallons of water which are brought by a sharp fire to the full boiling point; *when boiling*, two wire

baskets each holding below 10 lb. are introduced and remain there only *a minute or two* until some of the prawns begin to float; the prawns will now be brilliantly red and fully cooked. In this way the prawns are subjected to the minimum boiling period and therefore lose as little as possible of their flavour and juices; moreover the shellers can at once get to work. If on the other hand a mass of perhaps 1 cwt. of prawns is placed in a moderate sized vessel such as a cast iron boiling pan, with a small amount of water, the water is instantly cooled to tepidity, the prawns have to remain simmering perhaps for hours, some prawns are uncooked and some over-cooked, much of the value of the prawns remains in the liquor, and the shellers sit idle and happy being paid by the hour. Hence plenty of water at full 212° F. and *small* quantities of prawns in wire baskets (or ordinary baskets or nets) to facilitate introduction and removal, are essential.

185. It has been the custom to boil the prawns in water containing 5 to 7 per cent salt. But it is now a question under experiment whether boiling should not be in fresh water; it has been found that prawns boiled in fresh water can be much more easily shelled than those boiled in salt water, and text books accordingly favour fresh water; it is possible, however, that there may be an unfavourable difference in weight. The matter is being fully examined in two localities. It has been found difficult to keep even boiled prawns over-night for packing next day; e.g., prawns boiled at Tanur where they are usually abundant, are not satisfactory if kept moist, on arriving next morning at the Beypore cannery. Probably a slight addition of boric acid or sodium hypochlorite would enable them to keep perfectly: on arrival a washing in warm water would remove most or all of the boric acid, while sodium hypochlorite simply becomes sodium chloride (common salt); any slight odour from hypochlorite quickly passes away especially on cooking. Possibly, since ice is seldom available, the American method mentioned below *s.v.* "oysters" might be useful, viz., preservation during the night in water in which 1 per cent of bicarbonate of soda has been dissolved; this though quite innocuous, could be washed off next morning especially if water slightly acidulated with vinegar is used, when sodium acetate would be formed and removed. Since prawns are sometimes received or available in large catches it is essential to use some ready and safe method of preserving them till next day;

shelling is a lengthy operation, and without some means of preservation, the canner may often have to restrict his purchases and packing of this very desirable fish.

186. Fortunately this is now possible, by adopting the use of 'semi-dried' prawns which were introduced as a complete novelty in cured fish several years age at the Government Fish-curing Yard at Tanur and are now very greatly in demand as ordinary cured goods. These are prawns prepared as mentioned in paragraph 184. Immediately after shelling, the prawns are salted in saturated brine (24° B.) for about 20 minutes, according to size; being shelled they absorb salt readily. The brined prawns are then placed on trays and *semi-dried* either in the open air or in a drier. Drying is only partial and is stopped when the prawns are so firm that fairly strong pressure between finger and thumb is needed to make an impression on them. In this condition they will keep perfectly good for many days according to climate, and always for some days. If the prawns were perfectly fresh when boiled—and no others should be used—and if properly cleaned, brined, and dried, they will develop no odour save that natural to fresh prawns. These semi-dried prawns may therefore be kept till next day or later especially if in a cool place with free aeration; on the Nilgiris at 6,000 feet elevation they keep perfectly good for several weeks.

When required for use they are soaked in warm water till sufficiently—not wholly—desalted, and are then canned as fresh prawns; cans of these prawns cannot, if the work has been properly done, be distinguished from fresh prawns. Obviously these prawns can also be utilized for prawn paste even when several days have elapsed after curing.

This method also enables à cannery to obtain prawns from other curing yards, and thus greatly to extend its operations. It can be extended so as to obtain other fish if properly light-cured at the source of supply.

If ice is available it will of course be utilized to keep light-cured fish cool till needed.

187. Shelling is a tedious operation and there is some loss of edible material; 100 lb. of prawns fresh from the sea produce from 35 lb. when shelled and ready for canning, small prawns losing more in shelling than large ones; the heads and shells when dried sell well as manure, containing 3 to 4 per cent of nitrogen.

188. The shelled prawns are then brined for a few minutes according to size; longer is not necessary since for canning the prawns do not require heavy salting, and salt penetrates very rapidly into the flesh freed from the shells. But prawns somewhat more heavily salted, have met with approval. Prawns are packed dry or wet; at Beypore they are always packed dry and are therefore dried like sardines, but on trays, till outwardly dry. The cans for prawns *must* be enamelled or double lacquered inside; otherwise the constituents of the prawns act on the tin and the fish become black and consequently unsaleable, very shortly. Some canners also pack the prawns in a calico bag which is then tied up and pressed into the can; in Beypore the lacquered can is lined with vegetable parchment. Other linings are mentioned all of which are intended to keep the prawns from direct contact with the tin plate; a new method is now being tried and if successful details will be published. There is every difference between the brilliance of the red prawns when just boiled and the same when taken out of a badly lined can a few months or even weeks afterwards; even with all present precautions there is a good deal of difference, especially after a few months. That the loss of brilliance is due to the tin plate is shown by the appearance of the inside of the tin which is blackened and shows the shape of the prawns which have pressed against the cover and bottom, even though protected by parchment paper; also by the fact that prawns preserved in glass retain their brilliance. It is now hoped, however, to have prawns canned in tin containers as brilliant as in glass.

189. At Beypore prawns are always canned in the cylindrical flat cans called 12 oz. cans, i.e., which hold 12 oz. of ordinary fish, but prawns do not pack close and 9 oz. is about the ordinary load. Dry packed prawns require considerable exhausting since there are large air spaces however closely they may be packed; this same fact renders processing more lengthy than with wet packed prawns, but not so long as cans of the same capacity if packed solid with ordinary fish.

190. Wet packed prawns, preferred by some to dry packed, are packed straight from the brine tubs, and when sealed down *weak* brine is poured in through a small hole which is then tipped. As explained elsewhere, cans filled with water, brine, or vinegar cannot easily be soldered securely, owing to the local formation

under the soldering iron of steam which forces its way through the fluid solder; hence it is usual to put in brine after the top is soldered; tipping is easy enough since it merely means a drop or blob of solder on a small hole. With solderless cans this difficulty does not arise.

191. Wet packed prawns require shorter processing than when dry packed, since the convection currents in the fluid rapidly transmit heat to all parts of the contents. But dry packing is more practised than wet. In an American official pamphlet No. 1 cans dry packed with only 4½ oz. of prawns are said to be processed for 1 hour at 240° F., while wet packed only require 11 minutes. This has not been tested, but at Beypore the cylindrical flats in which about 9 oz. of prawns are usually packed "dry" get up to 40 to 45 minutes, and this is found to be ample.

Curried prawns are in favour; these require merely an addition of curry mixture to the ordinary packing.

192. *Oysters.*—These are always packed in fluid. Only a few experiments have been made at the Government cannery and these were not continued partly for want of good material close at hand, partly because the contents of the cans, though perfectly sound, generally assumed a green colour inside the fish, probably due to the food of the fish. Much experiment is required to ascertain the best sort of cannable oyster and the best mode of conditioning oysters intended for canning.

193. The general practice is as follows:—On receipt the oysters are well washed to get rid of adherent mud, etc., and are then opened. The older fashion was to open by hand which is slow and productive of small fragments of shell of which it is difficult to get rid. The modern practice is to place the shells, round side downwards, on trays which again are placed in cars or trollies; these are run into horizontal steam chests or retorts, which are then closed and steam turned on at about 10 lb. pressure for 5 or more minutes, according to the size and thickness of the shells or the incrustations on them. On removal from the chest, the oysters are found to be gaping so that the meats can be easily removed with a short blunt knife; since the oysters are placed with the convex side downward the natural juice is retained in the deep shell and this is carefully removed, passed through a muslin sieve to remove fragments, and set aside to add to the packed oysters. It is stated that if oysters have to be kept over-night for packing,

they will keep quite well till next day, if *after full steaming* (in the opening operation) they are placed in cold water in which 1 per cent (of the weight of water) of bicarbonate of soda has been dissolved; the statement has not been tested in this tropical country. Oysters are usually packed 'wet,' i.e., in their own liquor which has been saved for the purpose plus a small amount of weak brine, of about 3° B., or similar to sea water. The number or weight of oysters in cans even of the same size greatly differs, but the labels should show the details. A so-called 1 lb. can (that is, one which will hold about 1 lb. water) is usually packed with about 6 oz. of oysters. Owing to the fluid contents cans are processed a comparatively short time, viz., from 10 to 20 minutes—according to the size of cans—at 11 lb. (240° F.); or from 35 to 65 minutes in boiling water.

Pickled oysters, i.e., oysters preserved in spiced vinegar, should only be canned in glass jars.

194. The following American canning recipe is given not only to show another mode of using oysters but as a type recipe in which other fish, e.g., prawns, etc., may be substituted for oysters; it is also obvious that the macaroni and cheese may be canned without the oysters. On the other hand, except in camp or travelling, most housewives will prefer to make their own fresh macaroni-cheese, and add oysters, etc., from a can. Take, say, 10 lb. macaroni, cut in a slicer to 1 inch length, submerge in water at 212° F. but do not continue the boiling; remove after 5 minutes when the macaroni should be somewhat gummy; add grated cheese to taste, e.g., from 2 lb., and from 2 to 3 oz. of ground white pepper; mix thoroughly. Then add 3 lb. of chopped oysters (prawns, etc.), with any liquor from the oysters; pack two-thirds full and add hot 10 per cent brine (or some of the 10 per cent brine in which the prawns are boiled); test, exhaust, and process for about 45 minutes for 1 lb. cans. This recipe has never been tried at Beypore but may readily be varied by omissions or additions or substitutions. The 10 per cent brine seems unduly strong or saline.

195. *Mussels.*—These nutritious shell fish, said to be more tasty than oysters, may be canned like oysters, but since the shells are thin, they require very slight steaming to open them.

196. *Crabs and Lobsters.*—These are extensively canned but, at all events in this Presidency, lobsters are not found and crabs are

too small for canning. The Japanese crabs of which the canned meats so largely find their way into the U.S.A. market, are of huge size.

197. *Smoked fish.*—These are not infrequently canned especially when light or mild-cured so that they will not, unless canned, keep good for export or for sale beyond a few days. Kippered herrings are commonly canned in the United Kingdom; in the U.S.A. smoked salmon is perhaps more usual.

In India smoked mackerel either merely gutted (and split) like bloaters, or else split like kippers, take the place of herring, but beyond a few experiments to ascertain possibilities, these have not been canned at Beypore, since the fish are generally too thin in flesh to render the can an attractive proposition.

Slices of large fish (seer, black pomfret, polynemus, etc.) are more possible; in this case the fish should generally be light-cured, sliced, and the slices rapidly smoked in a dense smoke and canned at once, with or without oil. But variations are possible; the fish may be more heavily salted and smoked and may then be cured whole (split) and sliced for canning. Only one experiment has been tried in canning large smoked fish, in slices, at Beypore. Hence a description of canned American smoked salmon may be useful and suggestive.

198. The salmon are cured in both ways, hard and mild. *Hard-cured* are treated as follows: the fish are gutted, split, cleaned and packed for several days in casks with about 1 lb. salt to 6 lb. of fish. They are then repacked in market barrels with a larger quantity of salt, apparently about 1 of salt to 3 of fish. When required for smoking, these fish are soaked till most of the salt has been removed, and then hard-smoked for about two days till they are well dried and thoroughly smoked. A subsequent special light smoking with a particular class of aromatic wood is also given. These fish are exported in ordinary wooden boxes, but when used for canning they are cut into *thin* slices, and packed in sealed cans with cotton seed oil, either in the ordinary small cans or in large ones, holding several pounds, intended probably for use by retail dealers who would sell the product in small quantities, a plan adopted at Beypore in the matter of sardines in oil.

Mild-cured salmon are treated as follows: the fish are cleaned, split, deeply scored and washed, artificially cooled and placed in saturated brine in casks where they are kept for two or three weeks,

fresh brine (or salt) being added from time to time. These casks are kept in cold storage at about 35° F. during pickling. They are then removed and repacked with fresh brine and again placed in cold storage. When required for smoking, the fish are desalted by short soaking and then smoked as above.

Sometimes the fish are cut into slices and smoked.

199. In India cold storage is not generally if ever possible, and indeed the elaborate procedure observed in the U.S.A., especially as regards mild-cured fish, seems unnecessary. The hard-cured fish at Tanur are only kept in salt for a day or two and can then be well smoked either in slow or in rapid smoke according to desire and the needs of the market. The 'light-cured' fish prepared at Tanur are only kept in brine for a few minutes or hours—according to the fish and cure required—and are then surface dried before smoking; if they are large fish *in slices*, the brining is very short, with smoking according to need; see the Fisheries revised bulletin on "The Curing and Preservation of Fish." Ordinarily when light-cured fish are intended for canning they will be prepared and smoked at the cannery itself, but it is obvious that since even light-cured and smoked fish will keep good for some days, the cannery can draw upon other yards for its supplies; still more so where hard-cured and smoked fish are to be canned.

These smoked fish should be a very acceptable delicacy especially in India where a savoury product is so much appreciated.

It may here be added that when the various fish-curing yards prepare light cured fish as at Tanur, canneries will be able to draw upon such yards for supplies in addition to their own, for light-cured fish when desalted will be found useful in many classes of canning, especially for pastes and smoked goods; light-cured mackerel or large fish can be desalted and either marinated, curried, or even put up plain.

200. *Fish extracts.*—There is a method of utilizing oysters, and probably mussels, and canning (or bottling) the products, which has never yet been tried in this country, viz., the preparation of 'extracts,' like Liebig's "extract of meat," from these shell fish. Possibly extracts from other fish are also feasible but no mention of such extracts is found in the text-books, except of course in cookery books where fish soups are common.

The extracts prepared in America from clams (Mya arenaria and Venus mercenaria) are said to be even more nourishing and

tonic than that from oysters, and an invaluable restorative for invalids.

The general method with clams is to open the shell fish as mentioned above for oysters (paragraph 193), taking care to preserve the natural liquor from the fish ; wash the meats free from all sand, etc., mince or pulp them in a mincing machine, add the liquor and a small quantity of water, boil the mass for an hour skimming the fluid during boiling, press the boiled mass to comparative dryness, and then evaporate the resulting fluid at a low temperative either to a pasty mass or to dryness. Any required condiments may be added to the product, usually when in the fluid state. It would seem preferable to add the natural liquor, previously just sterilized, to the fluid resulting from the pressure of the boiled mass; this would assist in retaining the flavour of the juice which prolonged boiling would impair; one recipe indeed expressly suggests this later addition of the liquor.

The fluid should be evaporated at the lowest possible temperature in order to avoid changes caused by heat, e.g., the coagulation and hardening of the albuminous constituents, the loss or alteration of flavour, etc. But since, even with salt, it is a highly putrescible substance, it cannot be slowly dried in the open air ; hence it can only be properly desiccated *in vacuo*. At Beypore there is a vacuum stove which gives a vacuum as high as 27 to 28 inches so that goods can be desiccated at or below 140° F. as a maximum ; this method has been successfully tried there as regards prawns and fish. Abundance of ordinary oysters and other shell fish are available in the various rivers and backwaters, e.g., at Kadalundi and in the Beypore river ; hence the method may be readily tried for oysters, mussels, etc.

The desiccated product should then be put up in hermetically sealed cans and sterilized like fish pastes.

From the above method the resulting product is purely an extract like that of Liebig's "extractum carnis," etc. But in other recipes the whole mass of fish meal or pulp, and juices is desiccated, reduced to powder, and is then combined with some farinaceous substance such as flour, biscuit powder, etc., and with salt, etc. ; this mixed powder forms a highly nutritious food. In two recipes the farinaceous and other additions are made to the pulped mass of clam meat and liquor *before* desiccation, so as to form a paste or dough which is then desiccated at as low a temperature as possible,

and the product reduced to a granular powder. It appears, however, that if this powder were strongly compressed by a machine like that used for stamping tesseræ, so as to form hard tablets, it would be a preferable method of preservation.

In one or two methods only the juice or natural liquor from the clams is utilized for extract and not the meat of the clam. In these processes the liquor which is contained in the shells is separated from the meats, filtered, and sterilized (boiled), and while one part may be used in canning the whole clams (either alone or more usually with mixed vegetables to form a stew or "chowder"), the other and chief portion is concentrated, if possible *in vacuo*, and canned in hermetically sealed glass jars; probably inside lacquered tin cans would also suit, since the clam meats, etc., are put up in such cans, and one recipe expressly mentions cans.

A Scotch recipe converts the extract of clams or other shell fish into a jelly by combining it with a vegetable gelatinizer (from sea-weed) such as Irish moss (carrageen); agar-agar from Japanese sea weed would equally suit. The method is that of opening the shell fish by steam or by boiling in a very small quantity of water in a closed vessel (autoclave), removing and pulping the meats, and straining off the resultant liquor, presumably using some pressure. To this are added salt and condiments and the liquor is then boiled with the necessary quantity of carrageen. The product is strained while hot and at once put up in sealed receptacles.

These methods may be adopted by canners (and others) in India; presumably, in this climate, all such products should be "canned" either in properly lacquered cans or, preferably, in glass bottles or jars.

It may be possible to utilize ordinary fish for fish extracts: no information is given in any text-book, but no reason exists why the experiment should not be tried. For such purposes there are many fish too coarse or big for ordinary canning.

CHAPTER VIII.

Fish Pastes.

201. These are deserving of great attention ; they are abundantly packed all over the world, but in India no such product was canned until the Government Cannery took up the matter in 1912. In many countries these pastes are economically and rightly made, at least partly, of what would otherwise be wasted, being such portions of fish as cannot be utilized in ordinary canning ; but in many cases even these by-products are adulterated with material which, like bread crumb, may be perfectly edible but is not fish. Hence the cheapness of some of these products ; it is hardly possible otherwise to manufacture small solderless cans saleable retail at one penny and wholesale at three farthings ; it has been said that three-quarters of the contents of some tins of fish paste are other than fish. A recipe for 'anchovy' paste was obtained by the writer and is practically repeated in a text-book, in which the basis of the paste is plain *herring* with fat, boiled rice, salt, red colouring matter, and a bottle of anchovy sauce or essence ; the recipe naively adds "It is of course possible to make this paste with real anchovies but this would be too expensive." But this can be more than paralleled by commercial recipes in other lines. In this Presidency the pastes made at the Government Cannery are absolutely pure, containing only sound fish cured or treated *for paste purposes*, not mere fragments from ordinary canning which indeed are scarce, since large fish, which chiefly supply fragments and debris, are not greatly used at the cannery. Moreover the fish used for paste are usually cheap enough to provide cheap pastes of the highest quality. The prawn paste is made solely of the freshest and best prawns ; mackerel paste is made from mackerel cured and smoked for the purpose. Of course various ingredients are added as will be seen from the recipes below, in order to make the fish into a viscid, well-flavoured paste ; these are not adulterations but necessary additions, such as butter, oil, spices, etc.

202. Before giving recipes as used in the Government Cannery or found—very rarely—in the text-books, it should be mentioned that fish pastes have not yet been sufficiently dealt with in India,

even at the Government Cannery. In the first place there are many highly nutritious fish which cannot be canned in slices or whole, being too coarse or bony, or strongly flavoured, or too big for canning whole and not big enough for canning in slices; e.g., cat fish, and many others. These could be made up into excellent pastes if the subject were studied by an expert with sufficient time for experiment, and the lack of this has been an insurmountable difficulty hitherto. In the second place, there are many untried recipes, actual and possible, for utilizing the fish at present in use, e.g., prawns, sardines, mackerel, bámin (polynemus), seer, pomfret, etc. Some of these will be given or suggested below. What is insisted on is that pastes can be made of various fish, by different recipes, of fresh fish or of cured fish, etc., and that these pastes will not only utilize fish not largely used when whole on high class tables, but will provide food in a very portable and economical form, since pastes are made solely from the flesh of fish without bones or other useless portions, and are so consolidated that a considerable quantity of flesh and nutriment is contained in very small compass. In this case, what Americans call "straight" pastes, i.e., simple pastes made solely of fish flesh, without any admixture of butter, flour, etc., may be prepared; the object is not to provide a delicacy or savoury but a concentrated food for domestic manipulation.

203. *Prawn paste.*—For this product prawns are boiled in 10 per cent brine and shelled as usual, or the fish may be boiled in fresh water, which makes shelling easier and salt subsequently added. The flesh is then passed through a cutter which breaks it up into somewhat coarse fragments and by a second and finer cutting into a granulated mass. This mass is then transferred to a marble or polished slate table, mixed with butter, oil, a little of the water in which the prawns were boiled, some salt (if needed), mace, and red pepper to taste. The mass is then rolled with a heavy roller of large diameter so that the paste may not be touched by the hands of the operator, until the paste is uniform and viscid. It may then, if necessary, be ground in a stone mortar. In order to give a slightly increased or stronger flavour to the delicate paste a little essence of anchovies or anchovy sauce may be added. Water should be added if the paste is too thick or too strongly flavoured milk is also added in some cases and renders the paste milder. The smooth viscid mass is then packed, usually in 4 oz. cylindrical

tins, holding just 3 oz. nett; a spoon is used to force the paste into the can, which is then capped, tested, exhausted, tipped, and processed in the usual way. Either capped or strip-off tins with keys, may be used.

204. A recipe much used in the Government Cannery is as follows:—

To 100 parts of prawn flesh add—

Forty per cent butter; 15 per cent groundnut oil; 15 per cent liquor from boiling vat; 2½ per cent flour; 0·6 per cent mace; 0·4 per cent paprika; 0·15 per cent black pepper; water as required. The vat liquor may be omitted and plain water alone used; butter may be lessened and milk added.

But as mentioned above, a little anchovy essence gives more flavour and character to the paste.

205. A recipe used for "devilled crab" may be useful for prawns, viz.

One lb. butter or margarine, 1 lb. flour (or biscuit or bread powder), 8 to 10 lb. milk, 2 oz. chopped parsley, 2 oz. minced onions, 4 oz. salt, ½ oz. ground white pepper, ½ oz. ground red pepper; melt the butter, add the flour and milk gradually and bring to the boil, then adding salt, etc. Mix in with this enough prawn flesh, cut and ground fine, to make a paste of proper consistency.

The recipe is given to show what varieties are possible, according to the inventiveness of the canner and the tastes of the market; this particular recipe has not been tried at Beypore.

206. *Prawn savoury.*—This is identical with prawn paste but is ground up with various condiments and spices (e.g., cummin, coriander, chillies, etc.) to taste; every canner must select his own recipes.

207. *Smoked mackerel paste.*—This paste was intended, in the absence of herring, to imitate the well-known bloater or kipper paste of British firms. Large sardines may be and have been used with great success, but unless large and fat, these fish are rather troublesome to paste, small ones not having enough flesh to warrant the trouble. Good mackerel as large as possible are gutted, split, brined, and smoked in the usual way (see "Preservation and Curing of Fish"); the brining is light and the smoking so conducted as to be as *rapid* as possible, viz., a *dense* smoke in a smoker nearly closed at the top so that the fish are kept fairly

moist yet thoroughly penetrated by the smoke produced by a mixture of teak dust and paddy husk; if the fish are smoked slowly in a smoker with strong draught, the fish become dry and hard, and must then be soaked to such an extent as to lose most of the salt and smoked flavour, and even then much flesh will adhere to the bone or be unduly hard. Properly smoked mackerel for paste should be fairly tender, bright and light in colour; they must then be used *at once*, and not left to taint, mould, or otherwise spoil. The freshly smoked fish are then dipped a few at a time and only for a minute or so, into water at full boiling temperature; on removal the flesh can be readily stripped with a fork from the bones with comparatively small loss. The flesh is then passed through cutters, mixed with pepper, some of the liquor from the boiling pan in which the fish were steeped, butter, oil, water, etc., according to the state of the paste and the character required, rolled, ground, and packed, etc., as mentioned for prawn paste.

The character of the paste may be varied so as to be strong or mild in flavour; this may be effected by the duration of brining, by the character and duration of smoking, and by the addition of diluent materials such as milk, dry bread powder, etc.

208. It should be noted that pastes (prawn or other) appear to solidify in processing; a very soft, moist and viscid paste becomes much firmer in the can when processed; this must be allowed for by adding sufficient fluid; smoked mackerel paste is also apt to *darken* by processing.

209. *Other fish pastes.*—As mentioned in paragraph 202 many fish may be pasted and numerous recipes may be devised, though for *ordinary* fresh fish pastes simplicity should be the rule. A French recipe for cod paste may be used for pasting seer, etc. Take a fresh fish, cut it into slices, place the slices in milk and water (more water than milk), and heat until just *below* boiling point say 200° F., so as to sterilize it; remove from the fire and leave the slices in the fluid for about 15 minutes; then drain, remove skin and bones and pound it—perhaps with minced cooked onions—till it forms a creamy mass; some thick cream sauce may be added if not sufficiently moist. Spices may be added to taste. Pack, and process according to the size of cans.

It is obvious that this recipe may be varied to any extent; the addition of milk to water in which the fish is simmered, is excellent; in Beypore milk is frequently used for pastes, as it softens and

mildens the paste. Instead of cream sauce—which is specially for cod—butter as at Beypore, margarine, etc., may be used; ground pepper should be invariably added with of course any needed salt, without which a paste is savourless.

210. An American recipe for 'cod fish balls' (really for a paste which can be used for that favourite American dish) is as follows: this, under the name of 'fish pudding,' was seen in Japan also. But most housewives will prefer to make fish balls after their own recipes by simply buying salt or canned fish and mixing them with potato, etc., according to taste; the recipe is merely given as suggestive.

Take 100 lb. salt fish (cod in America), 125 lb. potatoes, 10 lb. raw onions, and 13 lb. pure fat (butter, margarine, etc.). Soak the fish in warm water to remove salt and then grind or pound to a pulp; boil, skin, and mash potatoes, and thoroughly mix the fish and potato with the onions and fat; salt (and saltpetre) with pepper and other condiments or herbs are added to taste. The mixture is then put into cans, usually 1 to 3 lb., sealed and processed.

This recipe can of course be followed (and varied) with any fish, which may, perhaps preferably, be fresh and not salt.

211. *Fish meal.*—This preparation is fish salted—in various degrees but not hard salted—dried and reduced to fine powder to which spices may be added. The powder or meal may then be put up, after thorough drying, into cans, closed, exhausted, and processed. Prawn powder is well known in India, but other fish meals are nowhere in the market. These meals are best packed in glass, but this is not necessary; when in tin these should be double lacquered and in the case of prawns, lined with vegetable parchment paper.

As the powder contains salt and spices and is thoroughly dried, hermetical sealing is not absolutely necessary for an immediate market; it may be put up in cartons or in lever top cans, etc.

CHAPTER IX.

Considerations special to Madras Canning.

212. In discussing the prospects of a fish cannery in the Madras Presidency, there are several considerations special to the Presidency.

213. *Location.*—At present the West Coast is decidedly the area most favourably known; it is possible that in that part of the East Coast northward of Masulipatam canneries may be possible, but at present it is the West Coast which is recommended; the water within 100 fathoms is far more extensive, the shoals of sardines, mackerel, and prawns are abundant, and larger fish are, at certain seasons, frequently available especially at certain places. Obviously the factory should be close to the sea-beach and landing places, near a centre of labour, and carefully selected as regards the abundance of fish and fishing population, and it should be near the best and cheapest means of transport whether road, rail, sea, or backwater; it is not however generally advisable to choose a city or large sea-port (e.g., Calicut) where the fishermen are apt to leave fishing for port work and where there is a keen market for fresh fish. The character of the nets and lines used (see paragraphs 79 and 148 supra) is important, and it should be ascertained whether large fish are fairly abundant; the statistics of the Government fish-curing yards will show this and other facts.

214. South Kanara from Kasaragod northwards, and Malabar from Tanur southwards, seem better for canning purposes than the rest of the Coast, though Cannanore and neighbourhood are convenient and well supplied with good fish. A neighbourhood to which the Ratnagiri boats and the Colombo curers will come, is usually a good canning locality. Mangalore and Malpé in the north, Cannanore in the centre, Ponnāni in the south, and the neighbourhoods, are localities that would repay investigation by intending canners. The presence of large and well supplied Government fish-curing yards is a useful indication. The proximity of a dispensary and medical service is highly advisable.

Fish and Materials.

215. For canning purposes, sardines, mackerel, and prawns are pre-eminent.

Sardine.—The oil sardine (Clupea longiceps) appears in shoals, often numerous and of large size, from September right through to May; they are probably present during the monsoon June to August as they are occasionally caught during fair intervals, and in spawn; but they are not usually in good condition for canning after February, being lean and comparatively tasteless, and mostly of very small size. The fish are caught in various nets as mentioned above, and are often procurable by the ton and at a cost of from Rs. 10 to Rs. 30 per ton; when of good canning size, say 10 or 12 per quarter tin, the ton will number from 25,000 to 35,000. They are mostly caught inshore within a mile or two from land, but the locality may be some miles from the cannery. Their irregularity is great not only from year to year but from place to place; in one year they may be abundant in Kanara and deficient in Malabar; they may be large and fat in one place and (as in 1919) small and miserable in another; in some months or weeks they will be abundant, but scarce for long periods; in some years they will be abundant all over the Coast, in others scanty. Hence a certain irregularity in canning, for though sardines may be had they may be costly and in poor condition and not suitable for first-class canning; moreover there are always periods of scarcity or total absence of fish, and from March to August it is often better, unless occasionally, to close sardine operations. Hence there must be a certain dependence on other fish or on by—industries if a cannery has, like a Government factory, to be kept open with full staff during the whole year. On the other hand it is possible to have a cannery with a mere nucleus staff, calling in solderers, packers, etc., only as occasion requires.

The other sardines (Clupea fimbriata or chàla mathi, and Clupea lilé) are not worth canning; the flesh of chàla mathi is of poor flavour, the fish lean and very bony.

216. *Mackerel* are even more uncertain than sardines but are caught along the Coast in vast numbers two years out of three, and all years in some number. A factory which in a good year could pack 100,000 cans of mackerel might in a bad year pack only 10,000. They are most excellent canning material, but need more care than sardines as they taint more rapidly.

217. *Prawns* are caught during most of the year, and in large quantities prior to and during the monsoon. They are a great standby for the West Coast canner, and give good profit.

218. *Large fish* are not everywhere available in quantity and only in certain months; at present much dependence cannot be placed on large fish which—if of the cannable classes such as seer, pomfret, bámin, etc.—are seldom obtained in large quantities under present modes of fishing; moreover, under present modes of handling or mishandling in the boats, they are often past the fresh stage when brought to the cannery, especially as there is everywhere a strong local market for large fish.

219. *Carriers.*—With the aid of motor carriers, or even of canoes (which might be fitted with a motor), a cannery could usually command fish, particularly sardines and mackerel, during the season, especially if ice is available. But this adds largely to the cost of the fish.

220. *Oils.*—As mentioned in the body of the bulletin, the oil question in Madras is one of much difficulty, especially at present; olive oil is out of the question; refined groundnut is scarce and very dear; cotton seed oil is hardly if at all obtainable; coconut oil is impossible owing to its specific flavour which cannot be disguised; gingely (til) oil is also of too strong flavour; A-1 sardine oil mixed with groundnut or cotton seed oil may be used for packing provided it is really A-1, viz., fine yellow, free from stearine, with but slight fishy odour and flavour; the slight fishy flavour is not objectionable with sardines being the fish from which the oil is obtained; indeed it enriches the flavour especially with poor class, lean fish.

221. *Fuel* is fairly cheap on the West Coast and very much is not required; good wood for the steam boiler may be Rs. 7 per ton: charcoal is abundant.

222. *Tin plate.*—At present this has to come from England or America: the present price is more than double the pre-war price. The gauge and quality differ according to the size of the cans and the mode of producing the cans. Cheap tin plate as often found in the Indian market, is a mistake, being of poor steel with an insufficient coating of tin.

Decoration.—Ordinary tin plates are plain, but they can be obtained as decorated plates which saves labels, lessens rust, and gives a very good appearance.

223. *Labels.*—When the plate is not obtained ready decorated, it must be labelled; labels of metal foil are neat and effective, and can be made to adhere firmly by a special cement and not by

solder. Paper labels should be of good glazed paper, and there are lithographic printers in Madras, Bombay, etc., who do very fair and artistic work.

224. *Varnish and lacquer.*—To prevent corrosion of the metal by fish packed with vinegar or by prawns, it is necessary to double lacquer the inside. To prevent rust and discoloration in this humid climate or to improve the external appearance it may be advisable to use a good lacquer, e.g., gold lacquer or a coloured spirit varnish, for the outside. These are dear and often of poor quality when bought in the local bazaar. In the absence of ability to make these lacquers and varnishes they should be procured from respectable firms.

225. It is advisable to stock very complete sets of samples of various classes of canned goods made elsewhere especially in foreign countries; the variety of such goods is surprising and is only equalled by—in very many cases—the excellence of their contents, of their packing, of their form, and of their decoration. Without such samples *constantly* in view, even the most imaginative canner loses many inspirations or ideas. The samples should be numerous enough to allow of the occasional opening of cans in view to examine packing methods, flavours, condition, etc.

To these should be added samples of various materials, especially of oils, lacquers, labels, etc., for comparative purposes.

COST.

226. *Land.*—This is not often very expensive, but good blocks are hard to get; moreover it is notorious that private purchasers of land in this country are often, by reason of Hindu and Muhammadan law, seriously troubled and injured by claims subsequent to purchase, made either honestly or vexatiously by co-sharers, in so-much that purchasers may find themselves involved literally in 20 years' litigation and expense with perhaps adverse decisions at the end. A clear, immediate, and absolute title is hard to get except from or through Government on its executive side.

227. *Buildings.*—These are not expensive; all may be single floor sheds, built on basements one or two feet above ground level; on the West Coast laterite is cheap and suitable for the masonry, and nothing is better than 'Mangalore' tiles (made at all important points on the coast) for the roof, and flat tiles on concrete for the floors; timber is also fairly cheap, being floated down from the

forests by river to the numerous saw mills ; excellent drain pipes are available at the various tileries.

The necessary cost of the buildings is therefore very moderate, and the actual cost depends on their size and the fancies of the canner.

Quarters should be built close at hand for all the more permanent and superior staff; this adds immensely to their health, comfort, and readiness to serve, and it is otherwise good policy in keeping them close to the cannery ; it also tends to protect the people from infectious diseases which may prevail in the neighbourhood.

228. *Plant.*—This has been described in the body of this bulletin : it is impossible to give actual cost since everything depends on the character and methods of the cannery, to which must now be added the great rise and uncertainty in the cost of machines. Exchange is sometimes favourable for buying in England such plant as steam-boilers, retorts and autoclaves, presses, guillotine plate cutters, etc. Much of the minor plant and fittings can be locally made, such as all necessary tanks and vats (metal, wood, or masonry), all solderers' appliances, small machines such as body formers and closers, etc.

Washing and lavatory appliances for the staff are necessary.

229. It is suggested that soldering work could be made more rapid and yet efficient with automatically heated soldering tools ; petrol air gas is easily and cheaply made and could be supplied under slight pressure direct to the tools as in modern canneries ; this would save a very great amount of time and insure the proper heating of the tools and the consequent fluidity of the solder and perfection of the joint. Cylindrical cans, moreover, of the *capped* variety can be closed in a second or two by employing proper *cylindrical* cappers of the size of the cap ; the cap and solder (in wire or drops, etc.) being in place, the tool is placed upon the can pressing it down centrally; the cylindrical capper is then revolved by one or two alternate half turns and the soldering is complete.

It is also suggested that in this climate where the edges of cap and can are apt to rust if the cans are made and kept in stock, so that the solder does not adhere—a cause of great loss—, the cap should be 'hemmed' which is the American technical word for caps edged by the manufacturer with just the amount of solder necessary ; this edging of solder prevents rust and waste of solder.

It is also suggested that the side seams of bodies, rectangular or cylindrical, should be of the locked (folded) class, which is not only far more secure than the usual clumsy lap joint but saves much solder. Key-opening cans are very desirable.

230. *Transport.*—A broad gauge railway runs along the whole coast, usually within a mile or two of the sea, from Tirur to Mangalore (175 miles), and good roads run parallel to and at right angles to the railway; the main coast road runs largely between the railway and the sea. The sea itself offers cheap and convenient transport, since coasting steamers from Bombay to Ceylon, Calcutta, etc., touch at several ports (Mangalore, Cannanore, Tellicherry, Calicut) and country boats are everywhere numerous. The backwaters also afford transport even by steam or motor launches, as from Ponnāni to Tirur railway station; motor lorries are also occasional as from Udipi (for Malpé) to Mangalore. Fish parcels are accepted by the railway at half parcel rates.

231. *Labour.*—As elsewhere in India, labour charges are low as measured in cash; at Beypore, regular labour including solderers may run from Rs. 10 (boys) to Rs. 14 or Rs. 18 per month; expert labour (maistries, smiths, carpenters, mechanics, etc.) from Rs. 22 to Rs. 78, and office staff at, say, Rs. 30 to Rs. 60: all include special post-war allowances for high prices. These are wages paid monthly and all the year round in the Government cannery, with pensions to the permanent staff; in private canneries it is probable that daily wages will be usual, only a nucleus staff being kept throughout the year, and other labour called in as required. Daily labour at the Government cannery runs about 8 annas for adult males, 4 to 6 annas for adult females, and 2½ to 4 annas for boys and girls. Piece labour is only occasional as in shelling prawns; it may become advisable in sealing packed cans as is done in France. Labour generally is quiet, obedient, and tractable as well as cheap and, in routine matters, follows fairly the accustomed lines when under supervision: gutters and packers do very well since the Indian workman is very deft-fingered. The people are eminently responsive to kind but firm treatment; they are very human and will take advantage of weakness but respond readily to kind masterfulness.

It is suggested that labour, both superior and subordinate, will be rendered far more efficient by the introduction of a 'bonus' or profit sharing system as in the Government cannery (and Soap

Works); work will be more active and more careful because more directly interested, economy and sound work will be more practised because they spell larger profits and therefore a larger bonus.

232. But Indian factory labour has serious disadvantages, mostly due to climate, heredity, and Indian conditions. It is slow, as might be expected in a tropical, enervating climate, nor do increased wages give commensurate increase in output, but tend to more frequent holidays; nothing, not even rewards, will induce solderers to turn out more than a moderate number of sealed cans such as, in a French factory under piece work, would be derisible. Labour, even superior, is apt to be slack; work which should be done by the superior or expert is apt to be turned over to the ignorant or half-trained hand with disastrous results; matters are put off till 'tomorrow' and forgotten; rules carefully based on common sense, knowledge, and experience are followed for a while, but their observance then tends to slacken and gradually disappear in favour of old, slack, stupid methods; the 'nitchevo' ('never mind') temperament breeds negligence, and ignorance leads to the strangest errors; rules are adhered to because they are 'orders' although the conditions may be totally changed, or a matter is neglected because there was no specific order. Hence the watchful presence of the master or manager must be *continuous*.

But given such master, one kind but firm, *ready to explain* reasons but insistent on reasonable obedience, *educating* his superior staff in the principles underlying practice, *sympathetic* with their difficulties whether in or out of the factory, and Indian (Madras) labour is pleasant to deal with, when due allowance is made for the fact that it works under Indian conditions which lack the industrial organization and traditions and habits of temperate climates and competitive business. Practically every worker in the Government cannery has been trained therein, and the superior staff has remained throughout.

233. Holidays are rather troublesome, partly owing to the admixture of castes and creeds. Christian holidays including all Sundays, are generally granted, though *necessary* work such as cleaning up after late operations on the previous day, is done; but to these are added very numerous Hindu and Muhammadan holidays. Probably 250 days per annum form a possible working year.

The people are apt to be delicate in physique and liable to malarial and other tropical diseases; while 'sickness' is not always the real reason for absence, it is much too frequently a genuine cause. Hence the provision or proximity of medical treatment is highly desirable, both as a matter of humanity and of business.

MISCELLANEOUS.

234. *Taxes and duties.*—The income-tax at about 6¼ per cent on net profits, and the land tax, are the only taxes outside the municipal areas within which latter there are the usual rates and professional taxes. Hence if a cannery is built, as recommended, *outside* of large municipal towns (Calicut, Tellicherry, Cannanore, Mangalore), only income-tax and the moderate assessment due to Government on the small area of land occupied, are leviable.

Customs duties are leviable on imported goods, viz., on machinery and on tin plate, solder, oils and other foreign material. For small canneries the machinery required is neither large nor expensive, and all necessary oils should be obtainable from local sources; tin plate should shortly be produced within the country.

Since all imported canned goods have to pay duty, locally canned goods enjoy protection to that extent, as well as by the expensiveness of labour in Great Britain, France, etc., and the high cost of freight.

235. *By-products.*—These are of two classes; one due to the disposal of waste or non-cannable material, the other for the utilization of unoccupied days, or periods such as the south-west monsoon.

A good deal of the fish obtained is useless for canning whether from bad condition or unsuitable quality or class of fish when bought *en masse*. Moreover there are guts and heads of all fish canned or utilized, the shells of prawns, etc. These are all treated by boiling and drying or simple drying, apart from the factory, or stored in pits; the product is a very good fertilizer readily saleable and containing from 3 to 5 per cent nitrogen when dry. If the fish are in good condition but unsuitable for canning they are salted and dried in the usual Tanur yard fashion. The oil used for frying finds a ready sale among boat owners for smearing and caulking their boats.

236. It is difficult to find work for unoccupied periods of perhaps a few days at frequent intervals, or for the three months of the

south-west monsoon. Probably the preparation and canning of jams, preserves, pickles, etc., will be a useful line of subsidiary work, since the raw material can usually be obtained and, though perishable, stores better than fish, especially if there is a cool room available. The preparation and packing (in tins or otherwise) of foods such as tapioca, so abundant on the southern parts of the West Coast, arrowroot, etc., would be useful lines, while the making and tinning of biscuits would also be possible. These are mentioned because all ordinarily involve in this country the use of tin containers, and, to some extent, the sterilizing arrangements used in fish canning.

237. Perhaps one of the most lucrative side lines of work would be the manufacture of empty tins for various business purposes and readily saleable in the nearest towns or elsewhere; e.g., tins for holding medicines, ointments, blacking and other boot pastes, samples, etc. Since, *ex-hypothesi*, the cannery has can-making machines, expert solderers, etc., they could be easily directed to these other lines in cans, whether solderless stamped from the flat, or semi-solderless seamed cans, or ordinary cylindrical soldered tins, lever top tins, or others; a small addition to the plant in the shape of dies would be all that is necessary. In the Madras Presidency it is believed that there is no regular factory for making the numerous classes of tins needed by or useful to petty manufacturers and the public.

238. *Refrigeration.*—In India modern enterprise in fish preservation naturally turns to refrigeration in one form or other. As regards the canner, his main requirements are either to keep the fish cool in the boats on the way to the cannery, or to hold over an excess stock of fish for one or two days while working through a heavy catch; it is not desirable to do more.

If ice can be locally made or obtained at cheap rates, nothing would be more valuable than an ice chest occupying a large part of a canoe or other carrier, in which the fish bought fresh from the fishing canoes could be kept cool (say even 50° F.) while coming to shore or while bargaining for further catches; it is waste of time and opportunity for a carrier to come in several miles with a small catch when other catches might be bought and taken to the cannery; in any case the fish will be the better for being kept cool *en route*.

In the cannery if an excess stock of fish could be put into a *cool* room, not necessarily or advisably freezing, but, say, 35° F. such excess might readily be kept for a day or two, specially if previously roused up with a little salt and a trifle of boric acid; this would enable a canner not only to buy sardines heavily when abundant and therefore cheap, but to work them off quietly without that undue haste which is apt to spell bad work from tired workers and consequent losses, and without the heavy expenses of overtime.

But unfortunately ice is rare and expensive on the coast and a very small machine is expensive to run, especially if not used regularly and up to full power.

239. *Profits.*—The question is often asked what profits may be expected. It is impossible to answer so crude a question where data vary in every possible branch of the work, such as locality, manager, supplies of fish, character of season, cost of materials such as tin plate, solder, oils, etc., character of the packing and goods, state of the market, and so forth. But this much is certain from the experience of the Government cannery, that if the cannery is well placed, built and fitted with due regard to economy and yet to efficiency, carefully run by steady and experienced men *preferably* by the capitalist himself as his own expert manager, even a small cannery, turning out only from 75,000 to 100,000 cans per annum, can make a fair livelihood for its owner and manager especially on an average of years; even the Government experimental cannery with its necessarily expensive, because permanently employed, staff, has done this, the net profits for the last 3 years having given a good percentage on capital after deducting all costs of every sort, including all staff and a fair share of the cost of the higher superintendence; during the year 1918–19, which was particularly unfortunate in the class and quality of fish obtainable, and when the price of tin plate, solder, oil, etc., was extremely high, the net profit was above Rs. 4,000; during the previous year it was higher.

The fixed capital in plant and pucka buildings exclusive of staff quarters and non-canning plant such as freezer with oil engine, and a vacuum dryer—is not quite Rs. 25,000, and this includes an expensive line of solderless can-making machines and many small items of purely experimental plant. The working capital of about Rs. 1,800 per month is not included, since it is regularly

replaced month by month with profit. It is, however, to be remembered that the Government cannery is not, primarily, out for profit; it has always been mainly a place for experiment, demonstration, and instruction, nor has it entered the market competitively. The ascertainment and publication of the best methods, products, and qualities, and the training of an expert staff, have been its chief duties.

In a purely business cannery there is no loss on experimental work or plant, a *minimum* permanent staff is kept, and all labour is dispensed with when not actually needed for operations; hence larger profits.

If to ordinary canning are added subsidiary lines of work for spare periods or even days as indicated above, profits may be raised considerably higher.

240. It is to be recollected that the canning industry in this country while suffering under disadvantages such as imperfect means of capture, careless treatment and delay in boats, a tropical climate and absence of ice and refrigeration, ignorance of unskilled labour and want of experts, the need for importing material, etc., as mentioned above, has also its advantages in the shape of cheap fish and buildings, the comparative cheapness of freight, packing and other charges in importing merely tin plate instead of vast masses of filled tins, a moderately protective duty, a (potential) abundance of the best oils, and labour which is cheap if not so efficient as in temperate climates. Hence there are opportunities of reasonable profit for men of the country who are prepared *thoroughly* to learn the industry on its technical and business sides, to practise it personally, intelligently, energetically and above all conscientiously, and to be content with moderate profits based on actual cost and not on comparative prices, for it is on the capture of a large, moderately priced market rather than on competition in a narrow high priced market, that sound profits depend.

Profits in a commercial factory depend mainly upon the management, its honesty, skill, and efficiency.

F. A. NICHOLSON,
Honorary Superintendent,
Government Fisheries.

20*th September* 1919.

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MANUFACTURE OF FISH OIL AND GUANO

BY

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INTRODUCTORY.

On the West Coast of the Madras Presidency, the *Clupea longiceps* or "nalla matti" appears in numerous and sometimes very large shoals between August and June. This small fish is known as the "oil sardine," since from August to perhaps February—varying very greatly according to season and locality—the adult fish are generally fat, often yielding from 10 to 15 per cent of oil when boiled and pressed in mere manual presses; even larger yields have been obtained on small parcels of very fat fish: at the Beypore Cannery these fish are frequently canned "plain," i.e., without oil or sauces, and in a can containing 7 oz. nett of fish it is not uncommon to find in the can half an ounce or so of oil which has exuded from the fish during processing. On the other hand there are years in which these fish are mostly young and lean, when the percentage of oil is but small, and in every year a large proportion of the shoals, especially after January, is hardly worth treating so far as the yield of oil is concerned.

The *Clupea fimbriata* (chāla matti) and *Clupea lile* are useless for this manufacture, nor is any other fish available except sharks, mostly small, for small quantities of liver oil.

The oil sardines are found to some extent about the same season of the year on East Coast north of Cocanada, but nothing definite is at present known about them.

On the West Coast shoals occur from Trivandrum (Travancore State) to Coondapur, and it is believed that they are equally or still more abundant on the continuation of the coast in the Bombay Presidency. South of Alleppey, however, the shoals apparently do not appear in quantities sufficient to render oil and guano manufacture possible; indeed Cochin seems to be almost the useful limit for such operations. From Ponnāni northwards the fish become abundant, and the South Kanara Coast seems particularly

favourable, since the small factories are very numerous and close together, while in the neighbourhood of Malpē the catches with the rampani net are often enormous.

2. No definite estimate can be framed of the catches since "Fisheries" have no statistical staff; the only figures at present available are those of the fish-curing yards and these merely show the weights received in those yards for curing with duty-free salt; the masses of fish sold fresh or turned into oil and guano are nowhere recorded. An estimate or rather guess in one of the bulletins mentions 100,000 tons as the possible aggregate of catches, but nothing definite is known. Perhaps the best proof of abundance is that within seven years from the establishment of the first (Fisheries) press in 1908, above 250 small private factories followed suit and were at work along the whole length of the Malabar and South Kanara coast. There are now (1920) over 600, many, however, being very petty and open to serious objection as will be shown below.

Moreover, during the year 1919-20 it is known that some 20,000 tons of "fish-guano" (dried "scrap") have been exported and sent to planters and others; a single merchant bought 12,000 tons. Since, in round figures, 1 ton of dry fish-guano represents 5 tons of fresh fish, the above quantity would represent 100,000 tons, to which must be added vast quantities of fish consumed, fresh or dried, as edibles, and other vast quantities dried whole on the beach as fertilizer. Hence in a good year the catches may easily run above 150,000 tons on the Madras West Coast alone.

3. The important question whether large factories can be established in preference to or alongside of the petty factories just mentioned will be discussed after a full description of the conditions of the fishery, from which the answer will be deducible. It may be said, however, at once that at present the conditions are unfavourable for large factories. Hence, while describing the methods of advanced and large factories in order to present the results of enterprise and capital as examples of method towards which work should tend, the small factory, its needs, present methods, and the improvements immediately possible and desirable, will mainly be kept in view.

USES OF FISH OIL AND GUANO.

4. *Oil.*—The oil from sardines, like that from Japanese "iwashi," menhaden, pilchard, and herring, is made from the body of the

fish and is technically known as body oil or "fish oil" as distinguished from blubber oils, head oils, and liver oils. Fish-oil from its cheapness is often used as a cheap illuminant, either directly, or indirectly when converted into gas as in the Mansfield oil gas plant. The commoner sorts, usually brown or almost black, are largely used, mainly by reason of their cheapness, as baths in tempering steel and in batching jute, while the better sorts, brown to yellow, especially when refined, are extensively used in leather dressing, in making dubbin for leather goods, in the manufacture of saddle and harness soap, and in arsenals for use in "browning" rifle stocks, etc. These better qualities are also used, usually in mixtures, for lubrication, and they are also used to some extent in paints for out-of-door work. The stearine, or fish tallow deposited from the oil, also has its uses in coarse lubricating work as in greasing brick moulds and in smearing and caulking vessels and boats, and in mixtures for waggon grease; insecticidal soaps made from fish-oil stearine, with or without rosin, are very valuable for spraying purposes, and the refuse oil and stearine can be usefully employed in manufacturing lamp black. In some countries this body oil is considered to be therapeutically valuable; for instance in Cornwall the pilchard oil is considered by the fisher folk and others as a standard remedy, and the use of the finer sorts of sardine oil in wasting diseases is being examined in the Madras Presidency.

The sardine oils of the West Coast have been used or supplied for practically every one of the above purposes; large quantities were supplied by Fisheries during the war for military and arsenal purposes, for caulking and smearing country craft on Mesopotamian rivers, in leather work, for the jute mills, for insecticidal soap to planters and agriculturists, and to medical men.

5. *Fish-guano.*—The name "guano" has been generally employed to distinguish the residue ("scrap") obtained by drying the tissue and osseous material which is left after boiling and pressing the fish for oil, from the "fish manure" obtained by simply drying the whole fish on the beach (see below). This "guano" which, when commercially dry, weighs about 20 per cent of the whole fish, contains, when of ordinarily good quality, about 8 per cent of nitrogen and 9 per cent of phosphoric acid, but has occasionally yielded (from the Government yard at Tanur) as much as 9·3 per cent of nitrogen. These figures, taken from

West Coast sardine guano, are similar to those of menhaden guano in the United States of America, but these latter may be very slightly higher owing to the more severe pressing given in the hydraulic or continuous screw presses used in the United States, which reduce the residual oil to a minimum. The percentage of nitrogen and phosphoric acid shows it to be a valuable fertilizer, and as the stuff has been thoroughly boiled, it easily disintegrates in the soil and is therefore readily assimilable by plants. Moreover when properly prepared and not adulterated with sand, etc., it is fairly free from oil and insoluble matter, and being very dry, and almost free from odour whilst dry, it is very acceptable by planters since it is readily transportable and easily mixed evenly with the soil; its use is consequently growing rapidly in Southern India and Ceylon; not only among planters of coffee, tea, and rubber, but among ryots, as always in Japan, through the efforts of the Agricultural Department.

As a food for cattle and poultry it is useful, but in competition with cheap edible oil cake of vegetable origin, it is not yet in demand, though fairly well reported on by the Agricultural College.

In the United States, it is in great demand as a fertilizer, many thousands of tons being annually made from the menhaden in huge factories; this fish is mentioned below, in describing American practice.

U.S.A. PRACTICE.

6. The manufacture of oil and guano in America which will be taken as the exemplar of modern practice, will now be described in detail.

7. *The fish.*—In the United States of America the fish used for fish oils proper, i.e., body oils derived from true fish and not from whales, is almost solely the menhaden (*Brevoortia tyrannus* or *Alosa*), a fish of the Clupeid family averaging about two-thirds of a pound in weight, too bony to be generally edible, but containing abundant oil in its tissues. The unit of catch and manufacture is 1,000 fish taken as 666 lb.; the fish are not actually counted but measured or weighed by special arrangements; the oil and fertilizer are stated in terms of this unit. Being not very dissimilar, except in size, from the oil sardine and both belonging to the Clupeids, the

methods of dealing with this fish will be detailed for comparative purposes. Most of the particulars are obtained from United States publications, notably a paper by Mr. Charles H. Stevenson on "Fish oils, fats and waxes, and fertilizers from aquatic products (1898)", etc., a paper by Mr. R. Leon Greer on "The Menhaden industry of the Atlantic Coast (1917)" and trade papers.

8. These fish are found all along the Atlantic Coast from Maine (one factory) to Florida (one factory) but are greatly more numerous off the coast of Virginia and Carolina which, in 1912, had 31 out of the 48 oil and guano factories and dealt with more than half the total number of fish. It is found that the yield of oil not only varies greatly on the different parts of the coast, but also at different seasons and in different years. For instance, as might be expected, the fish of the northern (colder) waters, are much fatter than those of the south both as to maximum and average yields: as much as 20 U.S.A. gallons or about 146 lb., from 666 lb. fish or 22 per cent, have been obtained in northern waters in summer months, and 120 lb. or 19 per cent as an average for a month; in the Middle Atlantic States the best yield would be about 15 per cent, while for South Atlantic fish the maximum would be about 9 per cent, and in spring little more than 1 per cent. The average yield of the 1912 season was 13 per cent in the northern waters, decreasing southward steadily to 12, 8, 4, and 2 per cent according to latitude. Even in the same locality the fish are much fatter in some years than in others; in one year the yield in one locality was at the rate of about 7 per cent while next year it was little over 2 per cent. In one notable case no less than 50 per cent of oil was obtained; this was due to a quantity of fish being enclosed during autumn, which is the best season, in a bay which yielded vast quantities of suitable food. These facts have considerable bearing on West Coast results; the oil sardine is at its fattest immediately after the south-west monsoon, viz., from August to, say, December, and it is therefore probable that their fatness is due to the abundant feeding in the coastal waters due to the quantities of suitable food directly or indirectly provided by the numerous rivers which during and for some time after the monsoon, pour vast floods of wash from the forests and cultivated lands into the shallow waters of the coast. Moreover, since Indian waters are tropical it is to be expected that the yield of oil will more or less correspond with the lower (southern) rates off the

American coast, or at least that they will be comparatively low on an average.

It may be added as regards general yields of oil from the menhaden that, during the ten years ending 1898, the average yield of oil on the Atlantic Coast, taking all regions together, was just about 5 per cent; in the previous ten years, it was about 4½ per cent and in the six years previous to that period was about 6 per cent.

9. A curious fact is stated in a record of 1902, viz., that on the Maine coast—in the northernmost waters fished—these fish yielded in 1888 as high as about 13 per cent, in 1889 about 11½ per cent, and in 1898 about 10½ per cent; from 1898 to 1902 practically no fish were taken on that northernmost coast, and in 1912 there was only one factory in Maine. This apparent desertion of a coast by the menhaden is parallelled by a similar desertion of its mackerel shoals; it is not therefore strange that on the Madras West Coast the shoals of sardine (and mackerel) are found to fluctuate very greatly both in quantity and in oil productivity in various years and various localities: this aspect of affairs is all important when estimating the chances of large factories on the West Coast.

10. *Capture of fish.*—In the United States of America the menhaden (*Brevoortia tyrannus* or *Alosa*) were originally taken on the Atlantic Coast by the ordinary shore seine net, the joint property of the coast farmers who captured the fish which were used whole as fertilizer for their fields. These seines were of large size, up to 3,000 feet in total length, and were capable of taking several hundred thousand fish at a time if big shoals were available, and were evidently similar to the "rampani" nets now gradually coming into use in South Kanara. As the demand grew in consequence of the introduction of boiling the fish so as to obtain both oil and fertilizer, sailing boats operating the newly invented purse seine in the open sea, became general, and these were speedily followed and are now entirely replaced by steam and oil-driven boats, operating purse seines. The purse seines are enormous nets of the seine class, the bottom edges of which, after enclosing a shoal, can be drawn together so as to form a vast purse or bag from which but few fish can escape; it is said that some of these nets can take half a million fish—about 150 tons—in an hour if the fish are available. The nets cost up to Rs. 3,000 and are said to last

only about one season. The purse net, which is operated by very strongly built row-boats of about 30′ × 7′ × 2′ 6″, is drawn close up to the side of the vessel and the fish rapidly transferred. Some of the larger steamers will hold 300 tons of fish, but the general run is considerably smaller. As a rule, the steamers go out in the very early morning, and work up to a few miles out so that they can bring back their catches in the afternoon to the factory to which they belong before the fish have time to taint. It is said that perhaps 95 per cent of the fish are caught within two miles of the coast, but the place of capture may, of course, be many miles from the factory to which the steamers belong.

In 1912 the number of power-driven vessels was 147 of 13,569 aggregate tonnage, 118 being steamers and 29 petrol-driven. These operated 274 purse seines with 386 boats, and they took 1,061 million fish or about 353,000 U.S.A. tons (of 2,000 lb. per ton) which yielded 6,651,203 U.S.A. gallons (5/6 of an imperial gallon) of oil worth Rs. 46,56,000, and 88,520 U.S.A. tons of fertilizer including 37,536 tons of heavy, moist acidulated stuff, valued at Rs. 64,14,500.

11. *Factories.*—The development of the factory in the United States of America has naturally been from the primitive to the most highly developed plant and methods; from petty works costing, with plant, perhaps Rs. 2,000 or Rs. 3,000 and dealing at most with 100 tons of fish per season, to factories costing above Rs. 15 lakhs (half a million dollars) with a working *capacity* of some 66,000 tons in the season. Originally the farmers used the whole fish as manure; this was wasteful since the oil was lost, and mischievous because the oil was positively injurious to the soil. Next came the method of allowing the fish to putrefy in casks when the oil cells disintegrated and the oil came to the surface; the process was disgusting and the oil not less so; the putrefied residue was used as manure. It was next found that the oil cells could be ruptured by boiling, with a great lessening of time and nuisance and a great improvement in the quality and quantity of the oil, which was obtained partly by skimming, partly by pressing in rude manual presses. Finally came the method of steam cooking and power pressing which has now attained practical perfection, in so much that the maximum amount and quality of oil and guano are obtained with the minimum of time, labour, and nuisance; the fish are caught at sea during the day, brought at once to shore at the

factory, cooked and pressed at night, and the guano artificially dried and stored during the following day. Factories are provided with plant of the most modern type, and are capable, in the largest size, of completely dealing with 2½ million fish weighing approximately 750 tons (of 2,240 lb.) per day, and employing 200 hands; an ordinary factory will deal with about one-fourth of this quantity.

12. As mentioned above the fish are caught usually in the morning, in huge purse seines, loaded at once on steamers or motor boats and taken to the factory during the afternoon. The factory is usually built where deep water enables the steamers to run alongside, or else a pier is provided; the fish are then transferred to the factory premises either in large tubs or boxes of a given size (old plan) or direct by an elevator one end of which is lowered into the vessel's hold (new plan); they are then passed through a machine which weighs or measures the amount of fish; thence by a conveyor they pass either to the "raw boxes" (fish bins) or direct to the steam cookers whether vats or a continuous cooker; from the cookers they are removed either by hand or by another conveyor to the presses which are either hydraulic or continuous after the fashion of an Anderson oil expeller; the mixed oil and water passes thence to the various separating tanks, while the pressed material ("scrap") is taken to the drying ground or to the mechanical drier.

13. Hence a modern factory consists of the following main items of plant, viz., elevator, weighing machine, conveyors, one or more cookers, presses, and driers, with ample storage and arrangements for complete cleanliness and for minimizing the nuisance which is, to a certain extent, necessary when animal matters are dealt with in huge bulk for reduction to fertilizer. The pre-war cost of the mere plant (exclusive of buildings) of an average modern factory with one steam cooker, two presses, and one drier, and all etceteras such as boilers, engines, conveyors, etc., was said to be Rs. 75,000 and its capacity 200 tons per day. The processes and plant will now be described.

14. *Buildings*.—If possible these have two stories in order both to save ground space and to facilitate operations. The building material is frequently of wood but this seems objectionable for reasons of sanitation and risk of fire; the floors are usually of cement for obvious reasons of cleanliness. The fish bins and

cookers are placed on the ground floor, and the presses in the upper story; from the presses the oil, water, and scrap fall again to the ground floor where the plant is located for separating the oil and water and for drying the scrap. This method is only possible on the large scale by the general use of conveyors and elevators, but it does away with all need for pumping. The cookers, oil tanks, and driers are not necessarily, perhaps not generally, in the main building, but are in separate sheds or even in the open, but always on ground level. Proper lighting is of course provided, and means for flushing the whole factory with plenty of water. In some cases the factory is built out over the tidal water, so that refuse, foul washings, and the waste effluent water from the presses and separating tanks, are readily disposed of without nuisance.

Floating factories have been tried in America, but without much success and the method was soon abandoned, though it is said that recently the method has again been adopted on a very large vessel. By this method a vessel was fitted up with the necessary cooking, pressing, and drying plant, and being movable was able to seek out and follow the shoals; moreover, except to those on board, no possible nuisance could be caused, while all refuse, foul water, etc., simply passed into the open sea. Probably the main reasons for abandoning the method were (1) the difficulty of storing and handling large masses of fish and of the products in restricted and narrow space, (2) the ability of modern power boats to run their catches rapidly to land and return at once to sea, (3) the difficulty of separating the oil and water in continually oscillating tanks. Possibly a very large vessel might be successful. The method is only possible where the most modern cooking, pressing, and artificial drying plant is available, and this, with tanks and storage room, would mean a very large vessel. Otherwise, especially with Indian shoals, the idea is *prima facie* attractive.

15. *Removal of fish from boats.*—The old method was by tubs of 500 fish capacity, slung into the steamer's hold, filled with fish, and hoisted on to the wharf. The modern method is by a mechanically run bucket-elevator which lifts the fish from the hold and delivers them to the weighing machine. It is said that the elevator will do in one hour work that required five or six hours by the old method, viz., 200,000 lb. of fish from hold to receiving bin; this

enables the vessels to get back to sea with the minimum cost of time, wages, etc. But it requires an engine of about 25 I.H.P.

16. As the fish come up from the hold they pass through a machine which either weighs or measures the quantity of fish. Though menhaden are spoken of in numerical terms, viz., so many million of fish, they are not counted but weighed or measured; the accepted standard size of a fish is 22 cubic inches, so that a compartment of 22,000 cubic inches is supposed to hold 1,000 fish; as a matter of fact a "thousand" may be 500 or 2,000 fish according to the size of the fish. The weight of a "thousand" is conventionally estimated at 666 lb. so that three "thousand" weigh an American ton of 2,000 lb. These considerations are of importance in comparing the output of oil and guano with that of Madras sardines: it is further to be remembered that the U.S.A. gallon is only five-sixths of a British gallon of 10 lb. water.

17. From the weighing machine a conveyor takes the fish to the "raw box" or receiving bin which is often of enormous size; the depth is usually 10 to 12 feet, but the length and breadth of the largest in use is said to be 225 × 25 feet. The sides of these bins slope to the centre where a covered trough is traversed by a conveyor; by removing parts of the cover of the trough, the fish fall into the conveyor which takes them to the cookers.

18. *Cookers.*--The object of cooking is to break up the tissues and oil cells, and thus free the oil for removal; moreover, it not only does in a few minutes what took weeks by the old putrefactive method, but yields a far superior oil free from putridity, of fine colour, and comparatively valuable.

The old kettle with open fire and hand press soon gave way to the vat with steam heating; these vats, usually of wood, are partially filled with water, and are provided with false perforated bottoms below which are coils of perforated steam pipe; the fish are dumped into these vats, and the jets of steam, at perhaps 30 or 40 lb. pressure, not only boil the fish with great rapidity, but break up the fish and fat cells by their forcible impact. Sufficient water is provided to form a fluid medium through which the lighter oil ascends to the surface, where with the upper stratum of water it can be skimmed off either by hand, or by orifices and pipes at suitable level, or by a jointed swivel pipe. Sometimes these vats are of great size and the boiled mass is then left in them for two or three hours and the surface stratum of oil with water is run off.

This skimmed oil is usually, with fresh fish, of a pale yellow colour and is altogether of the first class; when it first ascends to the surface it is limpid and almost water-white but soon becomes yellow.

19. The boiled mass is then transferred to draining tanks, and the oil from these tanks is also of better quality than pressed oil. From the draining vats the mass is transferred to the presses. The actual cooking time is from 20 to 30 minutes, and it is obvious that there must be a large quantity of effluent water from boiling and draining vats, charged with organic matter and therefore highly putrescible and liable to be the cause of nuisance; moreover the organic matter is apt to be a loss of fertilizer unless it can be utilized direct to crops, trees, etc.

20. The most modern method, now general, is to substitute a steam continuous cooker for the open boiling and draining vats, which, in 1912, were found, it is said, only in one State, viz., North Carolina. This is a long cylinder some 40′ × 2′, provided with a longitudinal revolving shaft to which are affixed plates, blades, or wings ("flights") set at a slight angle; in this way the fish are constantly stirred and broken up, and moved, by the action of the bladed shaft, towards the discharge end. Steam is admitted, preferably by a numerous series of narrow pipes at the bottom of the cylinder set along the greater part of its length; it may also be admitted by the shaft which is then made hollow. The raw fish are fed into the cylinder by a hopper; no water is added since the fish and steam supply sufficient and since no skimming is possible. Arrived at the discharge end the fish with the mixed oil and water fall into a conveyor which takes them either to drainage vats or direct to the presses, the latter being now usual as saving time and space. The object of the draining vats when used is probably to secure drained oil which is superior to pressed oil, and also to minimize bulk and unnecessary fluid in the presses.

The fish remain at most 15 minutes in the cooker, and the capacity of a single cooker of the above size is said to be 120,000 lb. (60 U.S.A. tons) per hour. The capacity under the vat system depends of course on the number and size of vats employed. The amount of steam used per cooker is not stated.

21. *Pressing.*—The old manual screw press, usually set in a wooden frame, speedily gave way to powerful presses, generally hydraulic, and these again in recent times have been largely supplanted by continuous presses.

Where hydraulics are used the boiled fish is usually allowed to drain in draining tanks, and when sufficiently drained to be fairly solid, the stuff is forked out into cylindrical iron cages (tubs or "curbs") on wheels running on rails; these are run underneath a stationary press-head against which they are forced by a hydraulic ram below them; after being sufficiently pressed the ram is lowered, and the tub is wheeled away to discharge its press-cake which falls to the basement below. The oil and water from the tub flow on to the cement floor and also pass by pipes to the receiving tanks in the basement. The tubs, usually about 3 feet high and wide are made of stout rectangular iron rods or slats securely bound together by strong hoops; between each slat there is a narrow interstice through which the oil and water are forced: in the centre there is frequently a hollow core about 12 inches in diameter, similarly built up of slats with interstices which provides an exit for the fluids from the centre of the mass. The tubs are slightly coned as to be a little wider at the bottom than the top; this enables the press cake to be readily forced out by pressure from above.

22. The continuous steam press is a horizontal tapered cylinder, about 12 to 18 feet in length, built up of steel rods or slats, and provided with a tapered Archimedean screw built up on a hollow revolving shaft which traverses the cylinder from end to end; as the shaft revolves the screw forces the material forward from the feeding hopper to the discharge end, the pressure being caused by the gradual tapering of the cylinder so that the material is strongly compressed and the fluids forced out through the interstices of the slats; the pressure is sometimes regulated by a cone-shaped block which can be so adjusted as to lessen or increase the discharge aperture. The whole press is of the nature of the oil press known in India as Anderson's oil expeller. Steam can be introduced by the hollow shaft so that the material is kept hot and pasty. It is said the larger of these presses will efficiently press up to 100,000 fish (weighing when raw about 30 British tons) per hour; the smaller will press half that weight. The power required is heavy, being 50 and 35 I.H.P., respectively. The press cake as it leaves the press is said to contain about 4 per cent oil, 46 of water, and 50 of scrap.

23. The advantages of the continuous press are the saving of time and labour since the cooked fish are brought directly from the

cooker by a conveyor and fed into the press by a hopper; there is no waste of time or material, and the intermediate draining tanks are not needed.

On the other hand the pressure is so great that a good deal of material is forced through the interstices, and it is calculated that about 3 per cent more of dry guano (scrap) is obtained by hydraulic than by the continuous method; moreover this material passes into the oil and water and adds to the difficulty of cleansing the oil from impurities. But these particles of fish, known as "gurry," are to a great extent eventually recovered and separately pressed for oil and fertilizer.

24. *Drying the scrap (solid material; press cakes).*—The old method still used on the southern coasts is that of sun-drying by spreading the broken up "scrap" on platforms (barbecues) where they remain for two or three days. But, especially in the more northern coasts where the weather is less certain, the hot air rotary drier is now almost universal. This is a huge cylinder of iron, some 30′ to 40′ long with a diameter of 5′ or more; at one end is a large furnace and fan, at the other a receiving chamber, which may be double so as to save the dry dust which is blown out by the fan draught. The inside surface of the cylinder is provided with several sets of plates or shelves ("flights") set perpendicularly to the surface and slightly spiral, forming a sort of hollow Archimedean screw of small pitch; consequently, as the cylinder slowly revolves, these plates catch up the scrap and shower it among the hot gases within the cylinder. The spiral setting of the shelves coupled with the fact that the cylinder is set a few inches higher at the hopper end than at the discharge end and aided by the action of the hot gas currents, gradually works the scrap from the hopper to the exit.

The whole cylinder revolves; it has no central shaft, but is provided externally with two encircling steel tires which run on rollers; these rollers being driven by a 25 I.H.P. engine, rotate the cylinder by friction against the tires, or, conversely, they serve as mere bearings, the cylinder being then rotated by separate toothed gearing encircling the cylinder.

25. The wet scrap is fed in by a conveyor direct from the cooker; it enters by a hopper at the furnace end so that the wettest material meets the hottest furnace gases, and travels in parallel with them. These gases coming direct from the furnace are at a very high heat, and since the wet scrap is brought in thin showers

into direct and intimate contact with the gases, the moisture is rapidly absorbed and driven off by the forced draught caused by fan and chimney. Hence the drying is very rapid, a few minutes sufficing; indeed the danger is of undue waste both by scorching and carbonizing the material, and by driving off too much material as dust by the chimney; watchful control is therefore necessary.

It is obvious that the method is very economical since the fuel gases are brought into *direct contact* with the material, and where large masses--hundreds of tons daily--of very wet material of a cheap and coarse character have to be dried, the method commends itself as economical of time, space, and fuel. But it is only applicable to materials of coarse character.

26. The drying capacity of these driers is not clearly stated, the two chief authorities differing radically. One authority gives about 3 short tons (apparently *dried* scrap) per hour per drier, whereas the other gives 600,000 to 800,000 fish--weighing 200 or 266 short tons--*per hour* (sic) which would mean about 40 to 53 tons dried scrap. Seeing that an ordinary factory with two presses and one drier will only work off about 600,000 fish (yielding about 40 tons of dry scrap) per day of 12 hours, it would seem that the word "hour" should be "day" in the second authority; this would then tally with the first; moreover the very largest factory has a maximum daily capacity of 2,500,000 fish which, at 800,000 per hour, could be worked off in 3 hours by a single drier; this is impossible. Hence it may be taken that one average drier will turn out from 35 to 40 tons dry scrap per day of 12 hours with a coal expenditure in the furnace of 5 tons, to which must be added the fuel required to steam a 25 I.H.P. engine for rotating the drier.

Steam driers are out of the question for this class of goods, but the utilization of waste or exhaust steam or the hot gases from the boiler furnaces would seem to be possible.

27. As stated above, the material as it leaves the presses contains about 50 per cent of water; as it leaves the drier--whether drying ground or hot blast--it may contain about 10 per cent and is then commercially accepted as "dry": in this condition it can safely be stored without fear of decomposition or spontaneous heating. With a larger content of moisture it must be used at once and--for freight reasons also--in the neighbourhood.

28. The yield of dry "guano" (scrap) is stated variously. The average of 10 years over the whole Atlantic coast is stated at

138 lb. dry scrap, containing 10 per cent moisture, per 1,000 fish weighing—conventionally—666 lb.: this gives 20·7 per cent. Again from 12,000 to 15,000 fish, or 4 to 5 tons, yield 1 ton dry scrap, being a percentage of 25 to 20 per cent. It would seem that the very high proportion of 25 per cent must be due to contents of moisture above the normal 10 per cent. A million fish or 333 U.S.A. tons are said to yield between 75 and 85 tons; the mean of 80 tons gives 22 per cent. Hence from 22 to 20 per cent of the raw fish weight seems to be the average yield of dried scrap. This nearly corresponds with Indian yields from sardine.

29. Owing to difficulties of drying, cost of plant, and objections of neighbours to the vapours and odours, a great deal of the wet scrap from the presses is not dried but acidulated with sulphuric acid, at the rate of about 40 to 60 lb. strong (commercial) acid per 1,000 lb. of wet scrap; this dissolves the bones and prevents decomposition and the attacks of flies, and fixes the ammonia; it has the disadvantage of weight and moistness. During 1912 there were manufactured 50,885 short tons of dried scrap valued at Rs. 91 per ton, and 37,536 tons of acidulated scrap worth Rs. 48 per ton; this would equal about Rs. 102 and Rs. 54 per ton of 2,240 lb. Well prepared and well dried scrap should contain 8 to 10 per cent nitrogen (10 to 12 units of ammonia) and 9 to 10 per cent phosphoric acid; the average is said to be about 8 and 8·5, respectively. The above are pre-war prices, and are much higher now (1920).

30. The fish scrap has occasionally been used as cattle and chicken food, but apparently to no great extent. It is mostly ground up and used as an ingredient in compound or complete manures. It is said that about 250 lb., worth Rs. 11 or 12, are used to raise one bale (400 lb.) of cotton lint.

31. *Oil.*—Oil, originally a mere by-product in the manufacture of fertilizer from menhaden, has become of equal importance. As described above, the fish are cooked and pressed, and during the latter process the oil and water run out, are received in channels on the cement floor, and thence fall to the receiving tank, usually on the basement floor. If the cooked stuff is allowed to drain before pressing (paragraph 19 supra), the drained oil and water are similarly received, possibly in a separate tank as drained oil is usually better than pressed oil. In the receiving tank the oil and water and most of the solid impurities separate to a large extent, but a series of separating tanks are needed to complete the

separation. The first tank is usually large and deep, so that the oil, water, and impurities may have a considerable time to separate; by the time this is full the upper stratum will be mostly oil, and this stratum then flows over the upper edge of the tank into a smaller tank, which consequently contains mostly oil with some admixture of water; the process is repeated till, after passing several tanks, the fluid is almost free from water and impurities except a certain amount of both still suspended in a very minute form.

32. While it is necessary to separate the oil from the original water and impurities as quickly as possible—especially in hot weather—to prevent fermentation and hydrolysis, it is nevertheless equally necessary, for this very purpose, to wash the oil thoroughly with fresh water. In the American factories the various separating tanks are provided with perforated steam coils and water, and the oil which flows into them is thus submitted to the action of steam jets which, by their agitation, thoroughly wash the oil with pure condensed water. The washed oil is then allowed to settle and is separated in the usual way.

33. The water is removed from the various tanks by a simple arrangement on the principle of a Florentine receiver or vase, and is commonly called the "coffee-pot" which such vase resembles.

Another means of separation is that of a swivel pipe by which a short pipe jointed to a main pipe by means of a swivel, can be so set as to remove the stratum of oil, either by a pump, or by gravity if the tank levels permit, at any distance below the surface without disturbing the water stratum below the oil. Or a pipe with funnel mouth is fixed in the bottom of the tank and communicates with a lower tank; the funnel piece can be set at any height and when the pipe is open allows the fluid to be drawn off from any level to the lower tank where the oil which may still be suspended in it, separates in the usual way.

If the several tanks can be placed on different levels, the receiving tank being at the highest level and others in steps below it, the oil and water can conveniently be run off by gravity without the aid of pumps.

34. The tanks are mostly provided at the bottom with steam coils so that the fluid may be kept at a temperature of about 125° F.: this keeps fluid the whole oil and the stearine, a somewhat solid fat which accompanies the oil, and also tends to more rapid separation of the oil and water.

35. When the oil has been practically freed from visible water, it is usual to "cook" it, or rather to raise it to about 215° F., so as not only to sterilize it but to drive off any suspended water. The oil so heated does not perceptibly darken in colour when steam is used for the heating, while the oil becomes clear by the absence of water and suspended impurities. From the cooking tank the clear oil is drawn off into storage tanks.

36. The foul water from the separators is sometimes run into "catch-all" tanks, since a quantity of suspended oil and impurities is carried over with the water, and this is caught in the tanks. But in sub-tropical areas, this effluent water is so putrescible from its contents of organic matter that, especially in hot weather, it cannot be thus treated, and is simply run off into the sea.

37. *Quantity.*—As mentioned above (paragraph 8) this differs enormously according to locality, year, and season; it is stated that the yield may be as low as 1 pint (less than one pound) per 1,000 fish (666 lb.), and may be as much as and occasionally above 15 U.S.A. gallons (110 lb.) or nearly 17 per cent. Taking the whole Atlantic coast for 20 years, the average of localities and seasons is stated as 4·3 U.S.A. gallons or 31·5 lb. or just over 5 per cent. But the yield differed greatly in different years; e.g., in several years the aggregate yield averaged 6·84, 6·81, and 6·38 gallons, while in other years the average was 2·62, 2·79 gallons, etc. Similarly in given stations the amounts differed largely from year to year; e.g., 6 gallons in one year and 2 gallons in the next. As for locality it is stated that, as might be expected, the fish of northern waters are much fatter than those of warmer southern water; e.g., the yield of the north Atlantic States might be 5·76 to 6·39 gallons, and those of the southern 3·51. In 1912 the average of the northernmost States was about 11·55 gallons, while Virginia and North Carolina gave only 3·72 and 1·98 respectively. Curiously enough the fish seem almost to have deserted the Maine coast (northernmost State) since 1898.

As for season, it seems that the yield is much higher in autumn than in spring; presumably the fish, as on the Madras coasts, are fat with high, summer feeding, and store this as fat against the winter; during the winter this is self-consumed, so that in early spring the yield of oil may be 1 pint per 1,000 fish as against several gallons for the same locality as the average for the same year. It is reported that in one bay the food one year was so

abundant that in late autumn the yield was 48 gallons (351 lb.) per 1,000 fish, or above 52 per cent. But it will be seen from the figures that the average yields are very moderate, say 5 per cent, and that while northern fish may average from 7 to 12 per cent (according to years) the warm water fish may average below half that amount. These lessons are important for Madras.

38. *Qualities of oil.*—Formerly, and perhaps even still in some small southern factories, the oil was dark in colour and unduly odorous, but modern improvements in catching and manufacturing have brought about very different results.

The standard grades for crude oil are known as A, B, C, D representing "extra light crude" (A), "light crude" (B), "brown crude" (C), and "dark brown crude" (D); owing to the improvements the bulk is of the A grade. As is well known, crude oil obtained from fish while fresh is usually light and clear, with but slight odour and taste; if the fish has at all decomposed, the oil is darker, odorous, and bad tasted, and turbid from impurities which more easily pass out from the presses than the tougher fresh tissues. The rapidity with which fish are caught by the newer classes of boats and nets, and brought to the factory, and the speed with which the fish are cooked, pressed, and the oil separated from the fish and dirty water, mainly account for these improvements, while the general introduction of steam for all purposes, prevents all the discolouration and odour due to scorched fish or oil. Hence the importance of modern methods, and especially of the use of steam. It may be noted also that fish from the open sea and fat ones give a better coloured oil than those caught in bays or than lean ones.

39. The crude oil has, however, to be refined either by removal of the stearine ("fish tallow") and any remaining impurities, or by bleaching, or by both.

The crude oil contains a considerable percentage of a fairly solid substance like tallow, which is called stearine. Even at ordinary hot weather temperatures, say 80° to 90° F., this is fairly abundant, but as the temperature falls it becomes still more noticeable; moreover oil freed from stearine by mere decantation at, say, 90° F., deposits more stearine as the thermometer falls. Hence to secure an oil which, even in winter, shall remain fluid and limpid, the crude oil is chilled to about 38° F. either artificially or by waiting till winter, and the mass thus obtained is bagged and

subjected to powerful hydraulic pressure rising to 2,000 lb. per square inch; the oil so obtained is called "winter oil" because it does not deposit stearine even in winter.

The amount of stearine thus separated is not stated, but in case of sperm and probably whale oil, the percentage of clear winter oil obtained by this process seems to be from 67 per cent if pressed at 32° F., to 75 per cent if pressed at 38° F. Hence the proportion of solid stearine (plus "foots" or stearine-cum-impurities) seems to be from 25 to 33 per cent, or from one-fourth to one-third.

40. The clarification and bleaching of the oil are variously effected, but the usual plan is by admixture with caustic soda, or even with soda ash if the oil is acid (contains free fatty acids) at 212° F., or somewhat lower. This causes the formation of a soap which usually entangles most of the suspended impurities, while the heavier impurities are precipitated; on removal of the soap scum and decantation from the "foots," a clear, bright oil is obtained; the process not only clarifies but to some extent bleaches. A cheap and effectual method of bleaching is by exposure of shallow layers of the oil in wide shallow tanks to the influence of the sun; the layers of oil may be from 3 to 12 inches deep, and the effect seems to be increased, and dust kept out, by covering the tanks with a glass covering; this process is said to result in a clear light straw colour. But it should be noted that very little, if any, bleaching is needed if the oil has been made rapidly by the use of steam from fresh fish: "extra light crude" (A grade) requires little but clarification: on the other hand, intrinsically bad oil, made by inferior processes from tainted fish, and possibly scorched by open-fire methods, cannot be effectively treated though it may be somewhat improved, by any process commercially practicable.

The soap and foots resulting from the refining processes is sold at from 1 to 2 annas or thereabouts per pound, so that the process is not wasteful.

41. The oils thus treated are sold as "extra bleached winter fish-oil," "bleached winter fish oil," "light winter fish oil," and "brown winter fish oil." The higher class oils are used for illuminating, lubricating, and painting, and, down to light brown for leather currying; the dark oils are only used for tempering steel and other metal working. The finer oils are said to be better than even linseed oil in the way of standing weather,

but are somewhat harder to work with. If after clarification from foots, the oil is treated with sulphuric acid, and the sulphuric acid and precipitated matter entirely removed by washing and neutralization, the oil is said to mix well with paints and, if mixed with kerosene and graphite, to be a good lubricator.

42. The wholesale price of crude menhaden oil varied at from 22 to 30 cents per U.S.A. gallon (7·33 lb. of oil) in 1897—1902; it was 23 cents in 1912, from 26 to 33 cents in 1913, from 36 to 37 in 1914 (pre-war), while in June 1919 the price was 78 to 82. In the earlier years the refined oils were from 4 to 8 cents per gallon dearer than crude, according to class of refinement; in June 1919 the excess was 18 to 22 cents per gallon, winter bleached oil running at 99 to 102 cents (1 dollar 2 cents) per U.S.A. gallon as against 80 cents crude. It will be seen that with the rupee at 1*s.* 4*d.* or 32 cents, crude menhaden oil was priced—wholesale—before the war at about 11 to 18 annas per gallon; in 1919-20 with the rupee at, say, two shillings or 48 cents, the price would be about Rs. 1-11-0 or Rs. 1-12-0 for crude, and about Rs. 2-6-0 for winter bleached.

MADRAS WEST COAST.

43. *History.*—Fish oil and guano are, in the Madras Presidency, made only on the West Coast (Malabar and South Kanara) where shoals of the oil sardine (Clupea longiceps, nalla matti) appear, usually in great abundance, from August to June; probably they are also present, being frequently caught in fair intervals, during the South-West monsoon from, say, 1st June to the end of August, but the heavy weather and rains of 80 inches upwards, preclude both capture and manufacture at that season, which, indeed, seems to be provided by nature as a close season, the fish being at that time in spawn.

These are the only fish providing "body oil"; whales are non-existent, and the sharks, though numerous, are usually small so that "liver oil" is not much in evidence, especially as sharks are much esteemed as food. Nor is any other fish available for the manufacture of fertilizer, since every fish is used as food, even to the skin, while the shoals of mackerel and catfish are far too valuable, in every way, to be used otherwise than as direct food.

44. From time immemorial the oil sardine has been used either for oil or for fertilizer but in the rudest possible way. For fertilizer the surplus fish—formerly in large quantity owing to absence of

rapid and cheap communications—were generally dried on the beach, as at the present day, without salt, exposed, sometimes for weeks in showery weather, to the ravages of maggots, birds, insects, dogs, and what not, and to the loss of nitrogen and tissue by putrefaction; millions of the fish remain as mere shells, as may be judged by the fact that 5 tons of fresh fish may average only 1¼ tons of dry fish after deducting the adherent sand, whereas similar fish salted and properly dried, will average about 2¼ tons. Not only so, but the valuable oil is worse than wasted, for, under the powerful solar heat, the oil exudes abundantly and hardens into a gum like substance which agglutinates to the fish quantities of the sand on which they are dried; moreover in turning over the fish with forks, further quantities of sand adhere to the gills and interior of the fish. Hence, considering the intrinsic value of the fish as oil producer and fertilizer, this method is as wasteful as possible; the nitrogen and phosphoric acid which the agriculturist needs, are at a minimum, hardened oil and sand which are useless and even mischievous to him, are at a maximum; the oil which is industrially needed is entirely lost. Commercially the estate Agents of the coast give no guarantee to planters as to fertilizing contents, while in purchasing the stuff they allow 15 per cent for sand in fixing the price and deduct, pro rata, for any excess; the writer has seen a specimen from bulk which showed 42 per cent of sand. In South Kanara, and possibly elsewhere, where tobacco is largely grown, this plant is fertilized with sardine manure prepared as follows: the fresh fish are simply dumped into pits in the sand where they remain till absolutely rotten, perhaps for one or two months; the putrid mass is then forked out and applied to the growing plants. The stench is intolerable, and for some miles is almost unendurable even when merely passing by rail through the area. Here the waste in the absorbent sand pits must be as great as the result is atrocious.

If oil was desired it was prepared by filling old canoes with fish, pouring some (boiling) water on them and exposing the mass to the sun till complete putrefaction resulted, by which the oil cells were disintegrated and the oil gradually floated to the surface whence it was skimmed off and used; the mass was apparently too putrid for pressure or further use, and though some may have been used for manuring coconuts, etc., the bulk of it was thrown away. The whole process was so great a public nuisance that the

magistrates had to intervene and the method mostly died out. The oil was, of course, of the worst description and odour, but was useful in caulking and smearing the planks of country craft. A good deal of this oil was once exported, it is said, from Cochin, but the trade had practically died out before the end of the nineteenth century.

45. But in 1907–08 the Fisheries Department, then newly started (1906), took up this important subject and based experiments and suggestions on early American practice, viz., that of boiling the fish in large pans, pressing the mass for the oil in manual presses, and drying the press cakes as fertilizer. Success was immediate; the example of the Department and of an enterprising merchant, Mr. U. Choyi of Cannanore, was followed by nine small similar works in the same year, and these have continuously increased till the number on over 250 miles of coast now exceeds 600 while the output of dry fertilizer approaches 20,000 tons and that of oil may run to one-fourth of that weight in ordinarily good years. Such statistics as are available will be mentioned below.

46. This rapid development has had its disadvantages:

(1) the earliest methods were imperfect and even erroneous, and these mistakes have been imitated and popularized;

(2) buildings and premises were often, perhaps generally, unsuitable in structure and locality; if specially built they were generally built with a main eye to cheapness, and were, and are often dark, ill-ventilated, and not easily kept clean; they frequently found difficulty in running off the large quantities of waste, putrescible fluid and thus caused great nuisance; they are often located in crowded quarters to the great annoyance of neighbours;

(3) they were started and run on too small a capital from which many evils have developed, such as imperfect methods and plant, inability to modify such methods or to introduce improvements, inferior products further injured by adulteration such as the deliberate addition of sand to the fertilizer;

(4) the falling into the power of money-lenders, brokers, etc., owing to the individual weakness and need of capital of the manufacturers, and therefore inability to stand up against adverse seasons or to avoid selling at unduly low prices;

(5) the spoiling of the reputation of both oil and fertilizer by poor and adulterated products and consequently the loss of markets;

(6) the incurring of objections by the magistrates and sanitary authorities.

The minimizing of difficulties and the removal of these objections will be dealt with below.

47. *Catching.*—As stated above, the oil sardine is the only fish utilized in bulk for oil and guano on the Madras Coasts at present; only on the West Coast are there shoals of sufficient size, frequency, and quality to warrant their use in this manner. They are thoroughly edible fish especially when large and fat, and thus differ from the menhaden; indeed it is solely because they are caught in masses which cannot—owing to climate, want of cold transport, cold storage, etc.--be utilized directly as food, that these excellent fish are turned into oil and fertilizer; when fish taint in a very few hours, so that runners cannot take the fish more than a few miles, and when rail transport is scanty and infrequent, and unable, for want of regularity and importance of supplies, to put refrigerating vans on the trains, masses of fish must rot unless dealt with in this way. Moreover, it is to be remembered that the fertilizer obtained from the fish enables the soil to produce abundant crops so that they are really consumed indirectly as food or turned into industrial crops.

It is believed that the oil sardine remains on the coast throughout the year, though not always accessible whether by reason of the monsoon or by their retreating to deeper waters: it is noteworthy that the American fishermen declare that in the winter the menhaden are present but do not come to the surface.

48. On the West Coast of this Presidency methods are primitive in comparison with those in the United States of America. The general method of capture is by pairs of canoes worked by six or eight men per canoe and operating the "odam" or "paithu" net which, like the purse net of America, catches the fish by surrounding a shoal with a wall of net. On getting in touch with a shoal, the two boats separate and move round in a circle paying out the net as they go; on coming together the net is hauled in, the purse of the net preventing escape below, until the mass of fish is brought up to the boats to which they are at once transferred. Each boat may hold a ton of fish, and since in a place like Tanur there may be 150 to 200 pairs of boats, very considerable catches are possible if the fish are abundant. It is indeed on such occasions and places that, in the absence of oil and guano factories, and even in places

where several exist, such as Baikal, the whole beach for miles may be noisome with the odour of masses of sardine spread out, without salt or any preparation, to dry in the sun as a crude fertilizer (see below).

The boats seldom go far from shore, three or four miles being perhaps the ordinary limit, though they may be considerably further along shore from their landing place. This is partly due to the nature of the canoes with weak or no sails, partly to the fact that the fish so rapidly taint after capture: hence the boats keep near shore so as to sell the fish fresh. It is probably not for want of fish further out at sea, since numerous shoals are met with a few miles from shore; it is in general the inability under existing methods and material, to deal with more distant shoals. With power boats or even large sailing boats operating purse nets, many more fish could be taken and the catches would be not only greater but more regular. At present this improvement seems impossible; and the factories depend on inshore catches by numerous but weak powered boats and nets.

49. In the northern parts of South Kanara a very fine seine net called the "rampani" is being gradually introduced for the capture of sardine shoals, especially in sheltered bays to which fish resort in vast numbers. This net corresponds in great degree with the seine net formerly much in use by the American farmers as mentioned above; like that net, it can only be operated from the shore and consequently the arrival of shoals within half a mile or so from the beach has to be awaited. These nets have now greatly increased in size, from nets costing Rs. 1,000 and taking fish worth Rs. 2,000 to Rs. 4,000, in the season, to nets costing Rs. 5,000 and catching fish worth in some cases Rs. 20,000 in the year. These nets are usually worked on the half share system, half the proceeds going to the workers—perhaps 50 men for the large nets—and half to the owner of the net; but in some cases the workers themselves own the nets.

50. No statistics are available for the general catches, which indeed vary enormously in different years and localities, as also in the quality of the fish as regards size and oil contents. But since it takes five tons of fish to make one ton of guano, it follows that 20,000 tons of guano estimated as a minimum for last year, mean 100,000 tons of raw fish. If to this are added the vast quantities dried on the beach for fertilizer and other huge quantities

consumed fresh or cured in the yards, the quantity of oil sardines annually caught is seen to be very large ; and these large catches might be greatly increased by the use of power boats or by large sailing boats carrying two or four "dories" or canoes using the odam or purse net and taking the shoals somewhat further out at sea, aided by motor carriers to run the catches to shore.

51. *Factories : Character and localities.*—Though there were during last year about 558 factories, a wrong impression would be gained if the word factory is unexplained. The small size of these "factories" may be gauged by the nett output which, taken as 20,000 tons of dry guano, allows an average of less than 40 tons apiece, or 200 tons of fresh fish. Many of these factories are mere sheds ; some are adaptations of existing buildings ; those specially built are often ill constructed, and very different from the up-to-date cleanly factories of the American coast. They are frequently dark, ill-ventilated, with flooring not impervious to soakage, insufficiently provided with drains for the complete removal of the foul putrescible water from the presses and settling pits, without proper drying grounds, and with surroundings insufficiently cleansed from debris ; there is frequently, if not generally, want of good water-supply and use of clean water for the daily and complete flushing of the factory premises, while disinfectants such as those generally in use in places where dead animal substances—often tainted—are treated, e.g., chloride of lime, ordinary lime, phenol and other disinfectants, are practically unknown ; even in factories where intelligent supervision might be expected, the results are often unpleasant. Moreover, these factories are often not only crowded together and unduly numerous in certain localities but they are too frequently in close proximity to the village houses and acquire thereby the hostility of the residents and authorities. Sanitary matters and rules are further dealt with below.

52. These 558 factories are distributed along the coast from Cochin to Kundapur, a distance of above 250 miles, but by far the larger number (401) arein South Kanara, the northern half of this part of the coast, where the frequent occurrence of sheltered bays brings the shoals close to land. All factories are, of course, built close to the sea or to backwaters communicating with the sea, so that in favourable and crowded localities rents up to Rs. 100 per acre are paid.

The cost of the simple buildings and plant is very small, probably from Rs. 2,000 to Rs. 4,000, while some of the more objectionable "factories" have cost less, and are those which give the most trouble whether in their condition or in the adulteration of the guano with sand or with common beach-dried fish.

53. *Plant.*—This is of the simplest, viz., in general one or two iron boiling pans, of U-shaped section, about 8 feet in length and capable of taking at most a ton of fish, usually somewhat less, and built in masonry over an open fire : from two to four manual presses of very fair local construction on patterns suggested by the Fisheries Department, with a number of coir press bags, a couple of separating pits, and a storage tank for the separated oil. The drying ground for the guano should be a "barbecue" or platform of concrete or at least of hard earth, sufficient to accommodate two or three days output; this, however, is often lacking or defective, and much is dried on the sand with consequent disadvantage to the purity of the guano. A store for the guano usually completes the buildings, the oil being either kept in a masonry pit, or in barrels in the open or under a simple shed. A more or less complete drain, of earthenware pipes or an open channel, takes away the waste water, either to the sea or backwater or into the sand.

54. At the Government Yard, Tanur, arrangements though still simple are more advanced: there are good sheds, with roofs of corrugated iron supported on brick pillars, thus permitting complete light and ventilation ; the floor is cemented throughout. Two small copper boiling pans with open fire are in use for small parcels or experiments, but the regular pans are steam driven, being long narrow U-shaped pans with a perforated steam pipe under a false perforated bottom of wood ; the material of the pans is masonry, iron, or wood. Two experimental pans are made of 110 gallon hogsheads with a perforated flexible steam pipe down the centre : the barrel turns on trunnions, so that it can be tilted at once into a receiving trough. The ordinary longitudinal pans have large sluice valves, and after the best oil has been skimmed off, the mass is run off into drainage tanks or boxes, provided with perforated false bottoms through which much of the oil and water drains off into the separating pits; this oil is usually better than pressed oil, but is not now kept separate from the latter, the object of the draining being to render the hot mass less fluid and more easily handled. The manual presses are placed close to the draining

tanks, and the separating pits alongside the presses. The pits are sunk in the floor, well built and cemented, and so arranged that the oil and water automatically separate. For small work there are tall metal cylindrical separators which work very well but are not suited to commercial or large scale work. The barbecue is a concrete floor, also cemented, but is not large enough. The effluent water runs into a sunk tank whence it is hand-pumped into a trough which carries it out of the yard: unfortunately the sea has now receded some 200 yards from the yard boundary, and it is now impossible to take the water to the sea: this will be further dealt with below.

55. *Method.*—As originally started at Cannanore by the Fisheries officers and Mr. U. Choyi, this consisted in simply boiling the fish over an open fire, pressing the mass in a wooden press, separating the oil and water in a collecting pit by means of a "coffee-pot" arrangement, re-heating the oil to sterilize it, and then passing it into barrels; the fish guano was sun-dried on mats on the sand; the effluent water was run direct into the sea. Owing to the immediate success of this simple method, many persons followed the same plan, and except that the boiling pans have become larger, that the presses are compact ones of iron, and that barbecues are common, the above methods are still general.

The ordinary procedure is that the fish, often some hours dead, are thrown into heaps or kept in bins near the boiling pans which are then crammed with fish; these are slowly and imperfectly boiled by open-fire with frequent and laborious stirring by wooden spades or paddles; the mass is then removed in coarse coir bags to the adjacent presses whence the mingled oil and water run into a masonry pit from which most of the water is removed by a useful device called in America the "coffee-pot"; see below paragraphs 67—69. The oil is then generally boiled to drive off most of the water still suspended in it, and is then removed to a storage pit while the guano is dried on barbecues or on the sand and stored in bulk in a shed. The foul effluent water is carried off by a drain to the sea, backwater, or merely to a pit in the sandy beach.

56. The defects found are numerous:

(1) The U-shaped pans are often too large for the convenient, economical, and rapid utilization of the fuel: a pan, 8 feet long, between 2 or 3 wide and deep is unwieldy and difficult to heat either rapidly or evenly especially with crude, unscientifically

designed furnaces and setting of the pan. Very often the fuel is burnt on the furnace floor without any grate, and too far from the bottom of the pan ; the chimney has sometimes been set half-way along the furnace so that the further half was comparatively cold ; the chimney is often wrongly designed, usually with insufficient square area, so that the fuel is badly consumed with much smoke which escapes at the furnace mouth ; the chimney entrance is sometimes at too low a level so that the hot gases do not rise and surround the pan ; very often only the bottom of the pan is exposed to the heat instead of space being provided between the masonry setting and the sides of the pan ; if the pan does not boil quickly the heat is urged, which results in much of the fish, and consequently the oil, being scorched, especially since, in view to supposed economy, the pan is generally crammed with fish and a minimum of water is allowed. One such pan and setting built by a European firm had nearly all these faults combined, and it may, therefore, be understood how crude the arrangements may be in the case of Indian workers who of course have a minimum knowledge of furnace and heating work.

57. (2) Owing to the size of the pans, the mass of fish, and the scantiness of the water, it is necessary continuously to stir the fish both to minimise scorching and to ensure fairly even heating. But the above conditions render thorough stirring most laborious and yet imperfect, and much oil is consequently scorched, as shown by colour and smell, while many of the fish are under-heated. Moreover, owing to the want of water as a medium the oil seldom rises in any quantity to the surface, so that skimming with its result in fine yellow oil, is seldom practised, and all oil is brown and is obtained solely from the presses. Two smaller pans side by side and worked alternately, one being boiled while the other is being worked off, would be greatly preferable and would yield better results ; the small open-fire pans at Tanur are heated with great rapidity and yield excellent results. One reason for adding a minimum of water is that as draining tanks are not generally used the boiled mass would be too fluid to handle conveniently and without risk of seriously scalding the workmen (who are of course, usually but sparingly clad) when put into the coir bags for pressing ; hence it is better from their point of view to use only so much water as gives a fairly solid mass when turned out of the pan.

58. (3) The re-boiling of the oil for sterilising purposes is very defective and scorches still more of the oil; it is often performed in vertical cylindrical pans, heated by an open wood fire the flames of which play around the bottom and sides of the pan; it is obvious that the oil in immediate contact with the sides is very apt to be badly scorched.

59. (4) The separation of organic matter (fragments of fish, etc.) and dirty water, is apt to be imperfectly carried out; ordinarily, except where special instruction has been given by Fisheries officers, the separated oil is never washed, and the dirty oil is kept in wide pits which, though they may be covered with mats, necessarily admit the air pretty freely: the oil gradually deposits much of the impurities and water, but in the long process, gradual decomposition of the impurities occurs which gives an unpleasant odour to the oil, while the water, impurities, and air together cause rapid hydrolysis of the oil with consequent very great acidity (and rancidity) which may amount to as much as 50 per cent of free acids. It is because of this fact that means are being sought to counteract the acidity of the oil, whereas the true remedy is to attack the *causes* of acidity: acidity once set up can, of course, be neutralized by sodium salts, but this is a source of expense, while the rough soaps so formed are generally of little use or profit in such small factories, and there is very little if any commercial outlet for them. As shown below the oil should be thoroughly washed, freed from suspended water and stored in closed barrels.

60. (5) The want of a series of separating pits or tanks causes imperfect separation of the dirty water from the oil, with the result shown in item (4) supra, and with consequent loss to the manufacturers. It is frequently found by purchasers of oil that at the bottom of the kerosene tins in which the oil is frequently packed there is a stratum of dirty water; for this a percentage of the price is deducted or a lower price is fixed. Purchasers moreover are generally aware of the bad results on the character of the oil and reduce the price of oil found with this residuum.

61. (6) The want of proper barbecues (drying grounds) causes loss to manufacturer and purchaser. For if the guano is dried upon the sand, a certain quantity of sand is, either by accident or necessity or design, mixed with the guano; this forms an adulteration which not only causes a reduction in price, but spoils the reputation of both manufacturer and product: this is further dealt

with below *s.v.* "adulteration." With proper drying grounds of plastered floors or at least beaten earth, there should be no admixture of sand, etc., beyond at most 2 per cent: in Tanur it is, or was, less; a small amount is inevitable owing to the strong sea breeze blowing from the sandy beach over the drying ground.

62. (7) Owing to smallness of the factories and the slow character of operations conducted as above with crammed boiling pans, imperfect heating, and a minimum of workers, the fish are often thoroughly tainted before being boiled, especially when catches are plentiful and cheap; this spoils the oil and injures the guano. Moreover, this fact coupled with want of cleanliness in factory and surroundings, attracts or begets multitudes of flies which are probably a greater evil than the odours which are the chief subject of complaint.

63. (8) The effluent water from the separating pits is supposed to be carried away by drains to the sea: it is too often allowed to flow into the sand where it forms pools or swampy patches of noisome character.

64. *Tanur practice.*—At the Government yard, Tanur, these imperfections are avoided except that (8) is not yet properly dealt with owing to distance from the sea which has greatly receded.

Boiling is here effected by steam from a vertical boiler which heats up the water and fish with great rapidity, 30 to 35 minutes sufficing for long, somewhat narrow pans. This not only prevents any possibility of scorching but enables batches to be worked off with rapidity only limited by the number of presses; this rapidity is increased and economy effected by placing the sluice valve well above the false bottom (see supra, paragraph 54) so that when the mass is run off a considerable body of boiling water is left in the pans ready to heat up the next batch. Instead of cramming the pans almost solid with fish, plenty of water is used and this is increased by the condensed steam; the quantity of water is such that the pan contains water full of fish and not a mass of fish with a little water; the fish can easily be moved in the water. Hence the oil which is almost at once fluidized from the lower layers near the steam pipe, readily finds its way to the surface and is then skimmed off at once with a proportion of the water, by women with skimmers: when heating begins the first oil is almost colourless but gradually assumes a yellow colour; this skimmed oil is never deeper in colour than a bright yellow; colour deepens in proportion

to the length and character (steam or open fire) of the boiling and the want of freshness in the fish, which however, is seldom a fault at Tanur owing to the system of rapid steam boiling. It is possible to run off the surface stratum of water and oil automatically by a pipe with an orifice placed at the proper level, or by a swivel pipe to take off the fluid at different levels when the pans are not full, but with small operations and cheap labour hand skimming is very effective; still the automatic method is elegant, cheap, and rapid.

The skimmed oil is, at Tanur, kept separate from the drained and pressed oil being of very high quality, described by a British firm in England as "unique" and worth several pounds per ton above ordinary oil.

The considerable quantity of water in the boiling pans and the lengthy steam pipe further enable the heating to be rapid and equal; every fish is equally heated and the pans show inappreciable differences of temperature at various points when tested with the thermometer. Moreover, the boiling mobile mass is easily stirred and broken up or moved about with wooden paddles with the minimum of labour, while the high pressure (60 to 80 lb.) steam is itself an important and effective agent in the necessary stirring and breaking up of the fish.

65. On opening the sluice valve the mass of fish and water, except the water below the level of the valve orifice, readily transfers itself owing to its comparative fluidity, to the draining trough which is a masonry or wooden trough the bottom of which is just above floor level: a false bottom of wire gauze, plaited bamboo, coir mat or other material which will readily let water through but retain the fish, is fitted two or three inches above the bottom, and by this means the mass is readily relieved of much of its water; this addition to ordinary methods is important. A good deal of good class oil passes with the water, but is now sent direct into the pressed oil pits, since the pressed oil at Tanur is practically as good as the drained oil and little inferior to the skimmed oil.

66. The well-drained mass is then scooped into coarse coir bags holding about 80 lb. each which are found to resist the pressure of manual presses perfectly, while not allowing much of the solid matter to pass. Two bags are placed in the press, and when half pressed a third is added: the wheel of the press is run by three or four men, and a lever is added to give the final pressure. The

presses being bolted to the cemented floor, the oil and water run off by channels to the receiving pit, while the press cakes are carried to the drying ground, broken up, and dried in the sun, a process which takes from two or three days. As the rainy season (south-west monsoon period) is over when oil and guano are prepared, the sun does the needful with no expense save that of a little labour in spreading the stuff and in heaping and covering it at night; depredation by birds and dogs is minimized by sides and a roof of old mackerel net.

67. The separation of oil and water in the receiving pit is effected in various ways. One method is an adaptation of the "Florentine Vase" or separator.

Taking advantage of the different specific gravity of two fluids (e.g., oil and water) the ordinary Florentine receiver (or separator) is made as a tall vessel from which an outlet pipe opens near the bottom, as in a tea or coffee pot, the height of the pipe depending on the difference in the specific gravities of the fluids to be separated but always terminating somewhat below the normal maximum level within the vessel. Hence when the two mixed fluids enter the vessel the heavier separates and remain at the bottom; as soon as it rises above the lower orifice of the outlet pipe the lighter fluid can no longer pass up the pipe, so that as the vessel fills, the outlet pipe receives and finally discharges only the heavier liquid, the lighter one filling the body of the vessel.

68. In the separating tanks this outlet pipe is a box built usually in one corner of the tank; it may conveniently be formed by a wooden plank, metal sheet, etc., placed diagonally across the corner; it opens below at about 3 inches or less above the floor of the tank and, has an overflow at a level slightly below the surface level of the fluid in the tank; or it may be made just large enough to bale from, or a small pump suction pipe may be placed in it. By either method the watery fluid is taken to another tank where any remaining oil is gradually separated from it and removed.

69. Another arrangement of this class is that of dividing the main receiving tank into two unequal parts by a partition, water tight except at the bottom where a space of one or two inches is left between the partition and the bottom of the tank: the smaller of the two divisions acts like the outlet pipe of the Florentine separator, since only water with some suspended oil can enter it

after the fluid has risen above the level of the interstitial space at the bottom of the partition; the water is then removed as before to another tank. Of course in all cases the water passing off from the receiving tank or pit contains a good deal of oil since the separation is imperfect, much of the oil remaining still in suspension in the water; hence further separation is necessary.

There are other methods, though not practised at Tanur at present and not on the Florentine separator system; see for instance, the methods mentioned in paragraph 33 supra.

70. The general American system, however, as mentioned above, seems to differ from these, viz., in building tanks (or pits) in series, and probably of some depth so as to contain the largest quantity of fluid with the smallest surface; these tanks gradually fill and during this filling most of the oil separates from and lies above the water; when the tank is full the top stratum, mainly of oil, overflows the lip of the receptacle and passes into a similar tank or series of tanks where the process is repeated. Since oil is lighter than water the top stratum in the first tank is mainly oil with some water; in the second tank it is oil with very little water, till, at the end of the series, very little water remains.

71. But though oil and water separate rapidly as regards bulk quantities, there is always a certain amount of water in *very minute form*, suspended in the oil, and this separates very slowly and with difficulty by mere gravity; the cloudy, turbid appearance of the freshly separated oil shows the presence of water, and when such oil is stored in tall tanks for some weeks a considerable quantity of dirty water will be found at the bottom. It is this dirty water which causes hydrolysis and acidity, etc., of oil not thoroughly cleared of all water, and thus brings loss to manufacturer and consumer, the latter objecting to purchase not only acid (or even rancid) oil which is unfit for many industrial purposes, but to buy dirty water instead of oil. Moreover this water contains organic matter which also assists the hydrolysis. Hence further action is necessary and it is here (as in other matters) that Tanur practice should be followed. The separated oil is thoroughly washed with clean hot water, and if the water is salt (e.g., sea water) so much the better, since the salt is antiseptic, and since such water is of greater specific gravity than fresh water, it separates more rapidly from the oil. Grain salt or similar substances sprinkled slowly and, gradually on the surface of the oil, are also used as clarifiers; these

act mechanically by carrying down impurities as they sink through the oil; moreover dry salt absorbs water as it passes through the oil. The oil may be washed once or twice, the water being poured through fine sieves placed over tall separators, or the water may be agitated mechanically with the oil and allowed to subside or, perhaps best of all, pressure steam may be let in from open coils; the steam condenses in the oil and thus supplies the necessary hot water; the great heat from the condensing steam thoroughly sterilizes all organic impurities, while the jets of steam violently agitate the mass and thoroughly wash the oil. The washed oil is then separated as above.

It may seem strange to add washing water in quantity after taking trouble to separate the oil from the *original* water, but though the process is somewhat troublesome and involves a second separation it is not only worthwhile but *necessary* if good class oil is to be made and a good price obtained. In America this is not only a regular operation but the storage tanks are often left uncovered in the open so that the contents may be washed by the pure water of the rainfall: this might be adopted in India: moreover, the strong sun bleaches the oil in some degree, and also tends to revaporize much of the water.

72. After washing a further process may or may not be adopted; in Tanur it has not been found necessary since the oil has not been in large quantity and is always thoroughly washed, so that it then keeps good, with minimum deterioration from hydrolysis, if stored in closed receptacles (in tall iron tanks or in closed kerosine tins) where it is unaffected by light and air which tend to cause acidity and rancidity in impure oil exposed to them. This further process is that of heating the oil slightly above 212° F. so as to drive off any residual suspended moisture. As mentioned above the imperfect practice of the coast "factories" is to apply the heat of an open fire to a mass of viscid oil with the *certainty* of scorching much of the oil and thereby spoiling it in colour and odour; moreover the moisture is imperfectly driven off. With steam, as at Tanur, this can readily effected without scorching, or even deepening the colour of the oil; a closed steam coil heats the oil in a tub or tank to the required degree, say 215° to 220° F. when the moisture in the oil is necessarily vaporized. Other steam methods are obvious; an elegant apparatus at Tanur consists of a tall galvanized iron vertical cylinder, provided internally with a spiral closed

coil of copper tinned externally, through which pressure steam passes; the oil from a slightly elevated tank slowly enters the vessel at the bottom and as it passes upwards is strongly heated by the steam coil, the vaporized moisture from the oil escaping through holes in the cover, while the oil passes out by a cock and pipe direct to the storage barrels or other receptacles: the process is thus conducted almost automatically and without contact with the air, and the oil cannot be contaminated between the feeding tank and the final receptacle. But with oil prepared in a cleanly manner and thoroughly washed, this process is not found actually necessary at Tanur; probably it would be useful if the oil were made from tainted fish.

73. For factories which have no steam it is easy to sterilize and drive off moisture without open fire; e.g., by placing the oil in a metal vessel (e.g., in kerosine oil tins) and heating these in a bath of strong brine, either an ordinary salt brine or one of calcium chloride which is a cheap and readily procurable material habitually used in ice factories for making their necessary brine. These brines only boil at a temperature considerably above 212° F. according to the density of the brine; hence the vessels of oil placed in such a bath also attain a temperature which drives off any suspended water; this was successfully tried at Tanur before present methods were adopted. Yellow oil so treated deepens very slightly in colour, and of course cannot possibly scorch. The external brine bath is, of course, heated by open fire: the ordinary fish boiling pan of the factory would do very well in which case calcium chloride is preferable to sodium chloride (common salt) in the bath since iron is practically unaffected by a calcium chloride brine which can be raised to a very high temperature by an increase in its density, that is, by adding more of the material. Of course the water lost from the brine by boiling must be continually replaced.

It is suggested that if the oil were passed slowly through a spiral coil made of thin copper and of narrow diameter, which traversed a trough of strong boiling brine it could be very effectively sterilized and dried.

PRODUCTS.

GUANO.

74. Generally speaking, the solid product is that primarily sought, especially in western countries where it is greatly in demand as

a fertiliser, while the oil is secondary and is removed partly because of its intrinsic value, partly because its presence in the fertilizer is not only not required but is even inimical, partly because it has no manurial value and tends to clog the soil and delay the decomposition of the manure, partly because fertilizer containing much oil is apt to heat to the point of spontaneous combustion. Since it is obtained wholly from the sea it is purely an addition to the productivity of the soil; it is not merely a transfer as in the case of cattle manure, oil cakes, etc., from the soil to plants and animals and then —and only to some extent—a retransfer to the soil, but an absolute and valuable augmentation of fertilizing constituents; hence its importance to India and a strong reason for its retention within our own borders. Its quantity and value will therefore now be discussed.

75. *Quantity.*—As stated in paragraph 28 the weight of dry guano in United States of America practice is nearly 22 per cent of that of the fresh fish, or rather more than 1 ton per 5 tons; on the Madras West Coast the percentage is as nearly as possible 20 per cent. The difference is probably due to the factor of moisture. In the United States of America "dried scrap" in its commercial acceptation, refers to guano containing not more than "12 per cent of moisture" (Stevenson), but the same authority states that "it is not always that so large a quantity of water is eliminated and sometimes the finished scrap contains 25 and even 35 per cent of moisture," chiefly when it is to be used in close proximity to the factories. Probably, however, in fully dried "scrap" the moisture in the stuff, as it leaves the drier, "does not exceed 8 per cent;" it is the averaging of thoroughly dried and only partly dried scrap, as noted in the preceding sentence, that gives the higher average of moisture connoted by a 22 per cent yield. In giving the average of 10 years ending 1898, the yield of guano per 1,000 fish (666 lb.) is given as "138 pounds of scrap containing 10 per cent of moisture"; this is equal to 20·7 per cent on the fresh fish. Seeing that Tanur guano only contains 8 per cent moisture it is not surprising that the dry yield is only about 20 per cent and not 22 as mentioned for the United States of America. The fish guano from Tanur sent to England (Imperial Institute) for analysis, showed only an average of 8·4 per cent, though the samples were sent in an ordinary parcel and must have absorbed moisture since they were despatched in the moist season and reached England during

winter. Probably the thorough drying given to the Tanur guano by an exposure of two to three days in thin layers on a blackened barbecue to a tropical sun and strong breeze, very thoroughly dries the stuff; hence the yield at the factory of only 20 per cent.

The actual quantity of guano made on the West Coast varies according to season; in 1919-20 it was certainly not less than 20,000 tons, representing 100,000 tons of fresh fish; on the other hand, from statistics for the season 1920-21 it appears that this was an extremely bad season especially in Malabar; only 290 factories out of 646 did any work at all and that but scanty; it is estimated that less than 2,000 tons of dry guano were made; but see also paragraph 80 infra. It is difficult to collect statistics from more than 650 small factories which are not only inaccurate by negligence or absence of clear accounts, but by design, owing to possible taxation; moreover, the Fisheries Department has no statistical staff.

76. *Constituents and quality.*—The constituents of the dried Tanur guano are nitrogen (in proteins), phosphoric acid and lime in the bones, oil, water, and insoluble matter; potash is negligible. The following table gives percentages as reported by the Imperial Institute in 1913:—

No. 1 "Fish guano prepared at the Government Fisheries Station, South Malabar."

No. 2 "Fish guano prepared at the Government Experimental Station, at Tanur, South Malabar": (*a*) "Ordinary guano", (*b*) "Guano from large oily sardine."

	No. 1.	No. 2*a*.	No. 2*b*.
	Per cent.	Per cent.	Per cent.
Moisture	7·86	8·82	8·65
Crude proteins	49·22	53·65	56·40
Consisting of:			
True proteins	43·75	45·41	49·06
Other nitrogenous substances ...	5·47	8·24	7·34
Fat	6·69	5·38	8·52
Other organic matter	7·37	4·73	5·01
Ash	28·86	27·42	21·39
The ash contained:			
Lime	CaO 33·10	42·32	42·12
Potash	K_2O 0·85	2·17	2·19
Phosphoric anhydride...	P_2O_5 29·52	35·32	35·56

The following table shows the percentages of lime, nitrogen, phosphoric anhydride, fat, and water present in these three samples of fish guano from South Malabar, compared with the corresponding figures recorded for fish manure from other sources :—

	Lime CaO	Nitrogen N	Phosphoric anhydride P_2O_5	Fat.	Water.
No. 1	9·6	7·8	8·5	6·69	7·86
No. 2*a*	11·6	8·6	9·7	5·38	8·82
No. 2*b* ...	9·0	9·0	7·6	8·52	8·68
Fish manure from refuse (United Kingdom) ..	...	7·8	8·1	...	18·9
Dried menhaden scrap (United States of America)	...	8·0	8·5	...	Not exceeding 12·0

The maximum contents of nitrogen in a Tanur sample was 9·34, a very good percentage. American menhaden guano (" scrap ") is said by Stevenson to contain usually about 8 per cent nitrogen and 8½ per cent phosphoric acid. Other analyses give an average of about 8·3 nitrogen and somewhat less phosphoric acid with about 7 per cent moisture (unusually low for a bulk sample) and 7·3 of oil. Japanese herring (iwashi) guano is said in certain analyses to contain as much as 10·6 of nitrogen but only 5·5 of phosphoric acid, a very low percentage, 6 per cent of oil, and 10·2 per cent of water.

77. The contents of oil (fat) in the dry guano are considerable; the wet stuff is somewhat glutinous and it is difficult, especially with only manual presses, even to get rid of much of the water; still more difficult to express all the oil. The oil in the samples tabulated above average 6·86 per cent for Tanur guano, and this agrees with about 7 per cent in menhaden scrap (Imperial Institute Bulletin No. 3 of 1914) and 6 per cent in some Japanese, herring guano. Possibly the best menhaden scrap contains less oil than is here stated, since the presses used are of enormous power; on the other hand Madras guano in general probably contains a larger percentage as the pressure is inferior.

The amount of water in dry guano has been mentioned in paragraph 75 and does not exceed 8 per cent in good West Coast guano. With this small quantity of water the guano is fully dry in a commercial sense and will, so far as moisture is concerned, keep. perfectly good, even in bulk, for an indefinite time.

78. It may here be noted that until required for removal it is better to store guano in bulk than in bags; it is more easy to turn it over when in bulk and thus ascertain or prevent any possible fermentation by reason of moisture or undue heating by reason of its contents of residual oil. Owing to the presence of oil there is sometimes, especially in the tropics and when confined in a close space, just a bare chance of the mass heating; this is very slight indeed in the case of guano from which most of the oil has been expressed, but in the case of whole fish ("fish manure") merely dried on the beach and retaining much of the oil, this chance is considerable, and, in one important case, a very large parcel of this whole fish manure exported to Japan was very badly damaged by scorching from this cause. But no case of heating has been known in the case of guano, and the matter is merely mentioned by way of caution. Another small reason for storing guano in bulk rather than in bags is that rats cause great loss by *damaging* bags in order to get at the contents.

79. The analyses do not mention any insoluble contents such as sand.

In the United States of America such constituent should be negligible as the fish are taken by elevators from the steamer to the machines and are dried artificially and not by sun-drying on the beach; some insoluble matter may be derived from the contents of the intestines.

On the West Coast of Madras all guano is dried in the sun, often on the sandy beach, and at the best, as at Tanur, on open barbecues or platforms, practically on ground level; the strong sea breeze blows a quantity of fine dust over the stuff during its three days' exposure, and some sand is also unavoidably mixed with the guano in turning it over, removing, and storing it. This, however, should never exceed 2 per cent. But, owing largely to the greed of many middlemen who, on the one hand, beat down the prices paid by them to the manufacturer and, on the other, desire to increase their selling profits by weighting the guano, the percentage of sand has now become a notable constituent of much of the guano sold and a formidable enemy to the industry; on the one hand the manufacturers are tempted to add sand to balance the low prices offered by the middlemen, giving as a reason that the middleman will add it if they do not; on the other, the middleman wishes to increase his profits, and hopes to escape detection by

his client especially if he is able to sell direct to planters or cultivators. Hence the admixture of sand has become a scandal; the coastal firms buy from manufacturers or middlemen on the basis of a presumed and permissible or necessary contents of 3 per cent sand, with reductions for any excess; since they, of course, know what they are buying the price they pay at best is, of course, not the normal value based on the manurial value of an absolutely pure article, but a reduced price based on the presumption of 3 per cent admixture of sand.

80. It is understood that consignments were sent abroad in 1919–20 direct by manufacturers or their agents with results, owing to excess of sand, that may well destroy the reputation of the article (and incidentally that of the shippers) and ruin a promising trade. Indeed, the facts of 1920–21 show this very result; notwithstanding a very short supply of fish which, in a reliable, honest trade, would mean high prices owing to a competitive demand, the prices were much *lower* than normal by reason of a very weak inquiry for the guano; this short demand is expressly stated to be due to the gross adulteration with sand in previous years, especially in 1919–20, insomuch that in some cases European firms refused to take delivery of guano which, by reason of sand admixture, was not even up to sample; it is also stated that a consignment sent to Japan was refused admission to the country owing to similar adulteration. One consequence of this destruction or at least partial breakdown of a promising manufacture is that some factory owners abandoned the manufacture and reverted to the old practice of sun-drying the whole fish on the beach; such fish obtained higher prices, by even Rs. 10 per ton, than the guano partly because buyers cannot rely on guano to sample or reasonably free from adulteration; the price ran at only Rs. 50 to Rs. 75 per ton ex factory. It must, however, be noted that one reason for not boiling the fish for guano was the extreme leanness of the fish and consequent want of oil, so that it was cheaper to sun-dry than to go to the labour and expense of boiling and pressing the fish without commensurate return in oil; 5 per cent of oil is stated as the maximum output from the fattest fish.

For further remarks on this matter see below *s.v.* "Adulteration" and "Co-operation."

81. *Manurial value.*—As shown above fish guano practically contains only nitrogen (about 8 per cent), and phosphoric acid

(P_2O_5, about 8·6 per cent) as phosphate of lime, the latter element (lime) averaging 10 per cent of CaO. Potash appears to be about ½ per cent being below 2 per cent of the ash which itself averaged 26 per cent; hence it is negligible as a manurial item. Its composition therefore shows that while very valuable, it is not a complete manure and it should consequently be used in a mixture, especially compost, whenever a complete, all-round fertilizer is desired. It is very extensively used in Japan, the United States, etc., and is said to be beneficial for root crops.

82. The following price list (1912–13) of a coastal firm supplying planters, etc., with fertilizer, indicates both the estimated quantities of manurial constituents, the price required for the same and, incidentally, the comparative manurial value, chemically estimated, of guano and beach-dried fish :—

	Rupees per ton bagged f.o.r.
(1) Fish guano, guaranteed, 8 to 9 per cent N, and 7 to 8 per cent phosphoric acid	100
(2) Milled fish, 5 to 6 per cent N, and 4 to 5 per cent phosphoric acid	55
(3) Fish-manure (no guarantee)	40

Number (3) is the ordinary manure obtained by drying fish on the sand and necessarily contains much adhering sand which partly accounts for its low price.

Another analysis obtained from the College of Agriculture, Coimbatore, is as follows :—

Fish guano.		*Beach-dried sardine.*	
Water	9·77	Water	6·5 to 15·0
* Organic	66·28	* Organic ...	36·5 to 60·00
Insoluble—		Ash	18·4 to 41·0
Mineral matter ...	1·58		
Soluble—			
Mineral matter ...	22·37		
	100·00		
* Nitrogen	8·31	* Nitrogen ...	4·4 to 6·8
Phosphoric acid ...	8·82	Phosphoric acid ...	3·9 to 5·3
Potash	·40	Potash	·2 to ·7
Lime	10·11		

6

In another analysis the nitrogen and phosphoric acid in fish guano were 8·46 and 8·66, respectively, against 5·83 and 4·81 in fish manure of good quality which contained very little sand (6·86 per cent) as compared with most samples.

83. Since the manurial constituents are in organic form, viz., the nitrogen in the tissues and the phosphoric acid (as phosphate of lime) in the osseous parts, the manure is not so rapid in action as similar inorganic materials such as ammonium sulphate, sodium or potassium nitrate, calcium superphosphate, etc. On the other hand this very fact lessens any tendency to loss by leaching during rains or irrigation and, further, tends to improve the mechanical condition of the soil. Moreover, since the manure has been strongly boiled, the osseous matter is friable and readily disintegrates in the soil. Its action can also be quickened by powdering, and, in fact, it is usually ground fine when incorporated with other manurial matters by manure merchants; on the other hand when used by the ryot in a compost, such powdering is unnecessary and perhaps prejudicial; the fermentation in the compost heap does all that is necessary, and there is probably less loss and better admixture when the manure is in its natural state of coarse fragments.

84. The following paragraphs are taken from the writer's published bulletin (Fisheries Department) on the fisheries of Japan :—

" *Manures.*—This is a most important product, fish fertilizer being the most highly valued of all manures in Japanese agriculture (see Agricultural note). The herring and sardine are the fish almost solely used, herring being enormously in excess of sardine now that the latter fish is more extensively used as food, whether fresh, salted, dried, or canned. The herrings are chiefly caught on the coasts of Hokkaido, the summer herring being much fatter than the spring herring which is in spawn. The oil is extracted by steam heating and pressure, and the scrap is then sent out as manure. The annual product is about 110,000 tons, of which nine-tenths to four-fifths are herring and from Hokkaido; the value is from Rs. 112 to Rs. 120 per ton or 20 to 18·7 lb. per rupee, the latter price being the latest (1904) ascertained. The productive as well as pecuniary value of this manure, chiefly nitrogenous but also largely phosphatic, as proved in Japanese agriculture (see Agricultural note) which consumes practically the whole product, strongly commends its development on our own coasts and its use on our own fields so sadly defective in the above, but especially in the nitrogenous, constituents. Our sardine and mackerel

shoals provide abundant food and manure, if properly sought after and taken. Still better, however, would it be to supply the fish mainly as food to the people and thence indirectly as manure to the fields; this is happening in Japan where the demand for fresh and dried fish as food is causing a short output in the fertilizer product; but then, the Japanese take care that after all it is given indirectly through the excreta to the soil; while, in addition, large quantities of bean cake and some fish guano are being imported from Manchuria, etc., and from Siberian coasts."

"*Manure and oil.*—The manure and fish oil industry is one which should heavily repay capital and benefit agriculture to an untold extent. In Japan this industry—the two are of course combined since herring and sardine are the chief manure fish—has taken on an immense development since the Japanese are well aware of the high manurial value of fish. Here in India, its value is practically unknown; coconuts and tobacco occasionally get sardine manure, especially offal, on the West Coast; on the East Coast I have found no trace of its use except that the brine in which sardines have been salted is, in one place, said to be used for tobacco. Hence the introduction of fish manure to Madras fields awaits the use of an agricultural demand, and this can only be shown experimentally on the Government farms unless the district associations or well-to-do farmers will take up the matter in view of developing the double industries of agriculture and fisheries. Seeing that dried sardines can be frequently had in vast quantities on the shore at from Rs. 20 to Rs. 25 per ton, and that there is rail communication along both West and East Coasts, there is an obvious field for enterprise wholly irrespective of the export trade which ought, however, only to be utilized if an Indian demand cannot be worked up. One obstacle to trade is in the gross adulteration of the article with sand; this is partly unintentional as the fish are dried on the loose sand, some of which is gathered up with the fish. But Dr. Lehmann states that whereas the average of sand was 6 per cent a few years ago, it is now far higher averaging 39·56 (? 34·56) in 1905 to 1906, and a sample shown me in London had 44 per cent: these figures show wilful and gross adulteration which will damage the trade and crush the demand just as the Cuddapah indigo trade was similarly spoiled: one obvious result of an organized trade would be the stoppage of this adulteration and the production of a warrantable article. Probably the enterprise demands such knowledge, organization, and capital that European firms will at first alone tackle it, but there is nothing inherent in the business to keep Indian manufacturers from learning and extending it." (Note on Fisheries in Japan, paragraphs 153 and 228.)

85. The next following paragraphs are from the writer's bulletin (Fisheries Department) on agriculture in Japan :—

(100) *Fish fertilizer.*—Consideration of this manure is necessary not only because of its intrinsic value and the importance rightly attached to it by the Japanese, but because this Agricultural note is complementary to the primary object of report, viz., the proper development and use of the fisheries of India as supplies of food and manure. The following extracts from Japanese papers bear directly both on this object and on the importance of fisheries to farmers :—

"The only source of fertilizers other than those produced by the soil from which Japan has drawn during her long seclusion and still draws a constant supply, is the sea with its enormous wealth in animals and weeds. Yet the sea yields at present only a small portion of what it might be made to contribute to the fertility of the land directly by a supply of manures, indirectly by a supply of human food. Fishing, though the occupation of many people, is carried on as yet on rather a small scale and only in the proximity of the shores, and might be much extended by the application of modern methods" (Agricultural College Bulletin). This was written about 20 years ago, since which time the Japanese authorities, recognizing both the enormous sources of food, manure, and wealth in the sea and the weakness of its exploitation compared with its possibilities notwithstanding the vast quantity actually drawn from it by multitudes of fishermen, have most wisely laboured (see Report on Fisheries) so to organize the industry and trade that the deep sea and distant waters shall yield up their harvest for the sustenance and enrichment of the nation.

(101) But it is easier to organize and develop on land the demand for fish food and manure by 5 million farming householders working on 5 million farms, than to develop the supply of fish from the sea by a couple of million fishermen whose boats and gear require immense modification before they can cope with the increased demand, and who must, in any case, face new and great dangers in attempting to cope with it.

For this reason and because, while there is an increased demand for fish fertilizer, there is a still greater demand for fresh fish owing to pressure of population, to concentration of wealth in large and industrial cities, and to improvement of communications, the price of fish fertilizer has steadily gone up to above twice that of a few years ago and the supply on the market has diminished by about one-tenth. The following table gives prices in pounds per rupee for several years, the rise having

been steady throughout; the figures are taken from the official Statistical Reports of 1902 and 1906 :—

Fertilizer.	Pounds per rupee.				Remarks.
	1887.	1890.	1894.	1904.	
	LB.	LB.	LB.	LB.	
Dried sardine	35	30	25	14·1	Herring does not appear in the accounts till 1890.
Dried herring	...	25	23·5	13·2	

The prices of the last few years are the average of 16 principal towns for sardine and 23 for herring, and probably therefore slightly lower than the price paid by the farmer. These later prices are extremely high; for after allowing 1½ annas for phosphoric acid and taking N as high as 10 per cent, the cost of the latter in 1904 amounts to 10·6 annas per pound. Consequently, foreign sources of fish-manure are being sought, large quantities of oilcake are coming in from China, together with sulphate of ammonia and phosphates from other countries; the coal of Japan is also, of course, now yielding sulphate of ammonia. It is regrettable that the fishing industry has not been able to keep pace with the demand for fish fertilizer which, in Japan, is the most esteemed of manures.

(102) Fish-manure, like X, is essentially nitrogenous but contains a larger proportion of phosphoric acid. It is of several kinds; the ordinary sardine and herring simply dried in the sun on the sand; scrap which has been boiled and pressed for oil; and a low grade made from heads, vertebræ, offal, etc., of the larger fish. In 1882, the analysis of samples from seven different sources gave an average of about 10 per cent N and 4 per cent PA, the variations being from 7 to 11·7 of N and from 3 to 4·85 (in one case 5·96) of PA; the lowest figures were in all cases taken from an inferior class of sardine simply dried on the sand and containing a good deal of oil and sand, herring appeared to be superior to sardine as a manure, and the best analyses were from herring scrap from which oil had, at least in part, been removed. From 1882, it is believed that the general manufacture has improved, since the oil, a valuable by-product but positively harmful to the stuff as manure, is now largely removed by boiling and expression; sand, however, is still a trouble and specimens have been shown me in which sand formed 25 per cent of the sample, while even higher percentages are well known

elsewhere in this class of fertilizer; in this Presidency Dr. Lehmann finds an average of 34·56 per cent (Report for 1906). English reports give for fish guano in general about 5·9 per cent N and 7 per cent PA; Dr. Lehmann's Mysore analyses up to 1905 gave an average of about 6 per cent N and 5 per cent PA, the highest percentage of N being 8·72 and the lowest 3·96; the samples giving the highest (bungara, mackerel) and lowest (sardine) rates were neither of them "adulterated" and apparently both were merely sun-dried; the low percentages of N as compared with Japanese are probably due to the large percentage of oil· Subsequent analyses gave lower rates owing to the excessive proportion of sand. One Japanese sample of fish guano prepared merely from refuse (heads, tails, backbones, offal, skin, etc.) yielded when dried in a water oven, 7·85 per cent water, 6·15 N and 7·64 PA, a very good outturn for the class of material.

(103) *Amount and value.*—The 21st Statistical Report gives for 1904 the quantity of fish manure manufactured as 36,278,000 kwam equal to 3,627,800 Indian maunds or 299,293,000 lb. or 133,600 tons. The value is entered as 10·27 million yen or just 3·5 kwam per yen or 19·25 lb. per rupee; these appear to be manufacturing or wholesale prices, for, as shown above, the town market price in 1904 was below 14 lb. per rupee. Hence the price paid in the markets was about 30 per cent higher. At the average of 10 per cent N and 4 per cent PA, there would be about 13,360 tons N and 5,345 tons PA, or 1,336,000 and 534,500 units, respectively, worth at English rates £668,000 and £80,000, or £748,000 in the aggregate. Hence, neglecting the small value of the other constituents, the Japanese were paying per unit for N and PA at least 50 per cent above English rates and considerably above those fixed by Dr. Lehmann as fair Indian rates. Compared with the cost of N in X it will be noticed that 200 kwam of X contain 9·5 lb. of N and, if purchased, cost the farmer something over 2 yen, while 12 kwam or 100 lb. of fish containing about the same amount of N cost about 3·4 yen at 3·5 kwam per yen or 4·8 yen at 2·5 kwam per yen. Hence as stated above, X is by far the cheapest nitrogenous manure and its true money value estimated in terms of N has probably been understated.

(104) *Productive value.*—1,336,000 units of N will suffice for about 1,200,000,000 lb. of grain at 900 lb. per unit *plus* 1,650,000,000 lb. of straw, and since the PA amounts to 534,500 units or 11,972,000 lb. which at 10·5 lb. per crop of 900 lb. suffices for a grain crop of 1,026,000,000 lb., the PA in fish manure is nearly sufficient for the N. These figures show that the manure supplied by fish, though large in itself,

is small as compared with that supplied by X, since the N in the fish will produce only little more than one-fifth, and the PA two-fifths, of the grain producible by those elements respectively as contained in X. But the value of a fish fertilizer to the agriculture of a country is well displayed by the use to which it is put in Japan. Its value and the comparatively moderate amount yet in use and the diminishing quantity annually available, explain in part the anxiety of the Japanese Government to develop its deep sea fisheries; it is all very good to take in herring and sardine when they arrive at the door, but far larger supplies are needed for which it is sought to promote the use of much larger boats not only to seek and follow the shoals when found (as in the case of menhaden, etc., on the American Coasts) but to go to distant shores and seas (Korea, China, Saghalien, Russia, etc.), where fish are to be found in vast quantities. If this is the need in Japan with already 134,000 tons of fish fertiliser in use on good soils, the lesson for Madras is obvious.

(105) Fish is not generally used by itself (except, it is said, for indigo) but in conjunction with other manures, chiefly compost; it is a favourite manure on the tea plantations, which, in Japan, form part of the peasant farmer's ordinary cultivation on the plains; this shrub is said to be manured four times annually, the heaviest dose being given in spring; oil-cake and fish are said to be particularly effective, but in their absence and for the oldest plants, X is much in use. The dry fish scrap is pounded and mixed with fine compost for general use.

(106) Dr. S. Nagai mentions the preparation and use of a lixivium prepared from fish refuse as mentioned above, end of paragraph 102. The heads, guts, skin, bones, etc., of large fish such as the tunny, are collected from the fish dealers or from the restaurants and sent up country. The purchaser puts them into a vat, pours over them the hot bath water from the house (the Japanese bathe daily in very hot water), and repeatedly stirs up the mass, which is then covered up with straw mats and left to the putrefactive fermentation which rapidly sets in. After some weeks the putrified and partly liquid mass becomes of a dark greenish colour with a smell almost insupportable; the liquid part is removed and largely diluted when used; the undissolved residue is used with fresh matter for a new brew. It is said to cause a very rapid development of the plants to which it is applied.

The diagram for manures in the paddy field is here reproduced and shows at a glance the respective gross produce and the net profits obtained by the use of eight different mixtures, the gross return being marked by the red lines and the net profits by black; for instance, it will

be seen that while the largest *gross* return is obtained by using a mixture of fish (herring), phosphates, and compost, the *net* profit, by reason of the cost of fish, is only second, and far below that obtained by the use of a mixture of human excreta (X), phosphates, and compost, which moreover produces the third best gross outturn; this confirms one thesis of this note, viz., that human excreta are among the best and certainly are the cheapest of all the Japanese manures. It will be noticed also that phosphate of lime is an invariable component of the rice manures, an ingredient never added in India though bones are abundant. The effect of bean-cake is noteworthy especially as regards net profits; this manure is now being imported from Manchuria in immense quantities. The great value of fish as a fertilizer for rice is very marked and emphasizes the importance of developing its use in India.

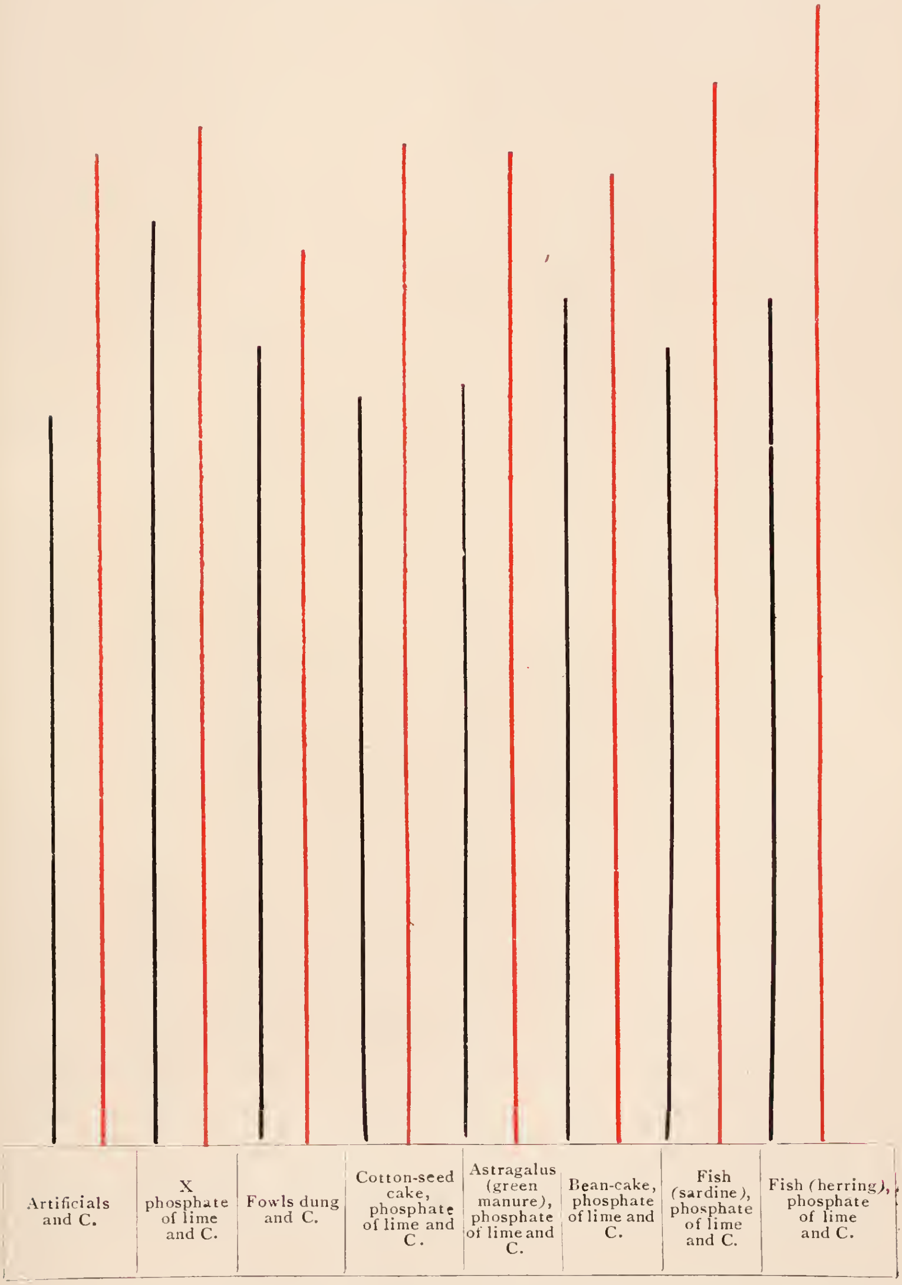
The importance of the subject must be the excuse for these extracts. It is to be noted that paragraph 228 from the bulletin on Japanese fisheries (and part of 102 from that on agriculture) relates not to fish guano which had not then been made in India, but to mere beach-dried sardine; it will be noticed, however, that the admixture of sand with beach-dried sardine was already a regular method of deliberate adulteration.

The letter X has been used in the above bulletins as an abbreviation for human excreta, solid and liquid.

86. As regards the use of fish guano and fish as manure in this Presidency the following information abstracted from Notes kindly supplied by the Department of Agriculture, is interesting.

Whole fish manure had to some extent been in use by the Department, but when guano was introduced by the Fisheries Department this was substituted as being free from oil; it has, also, other advantages. It is used largely on the Central Farm at Coimbatore for "garden" crops, such as millets and Cambodia cotton, especially as a top dressing, just before irrigation, to the ragi and cotton, at about 250 to 300 lb. of fish guano; this is in addition to cattle manure; when used with cholam it is mixed into the soil at the time of sowing. It was also used for sugarcane on the same farm and was successful until the present year when results did not come up to those of previous years. Plots of sugar-cane at the Samalkota farm in 1919-20 manured with guano of the same value as castor cake gave very similar results in weight of cane and jaggery to the plots manured with castor cake. At Manganallur (Tanjore District) after five years' experiment, it was

DIAGRAM SHOWING THE COMPARATIVE EFFECT OF RICE MANURES.



N.B.—Gross outturns are shown by the red lines; net profits by black. The letter C means compost or "manurial earth," invariably used in Japanese cultivation; see *s.v.* "manures."

concluded that 500 lb. fish manure (whole fish, *not* guano) applied to paddy, gave returns equal to 15 cartloads of cattle manure. At Koilpatti 5 cwt. per acre of fish guano gave results in sorghum fodder nearly equal to those with 2 cwt. Nitrolim. At Taliparamba (West Coast) fish guano is found very useful for pepper and the experimenter uses it largely on "garden" crops. At this latter farm, fish guano has given excellent results for the last 6 or 7 years on "all crops except ginger; for ragi, paddy, chillies, sugar-cane and coconuts this is the manure now being generally applied"; the difference between fish manure and fish guano is that "to get the same result" 2 cwt. fish manure are required to 1 cwt. of fish guano. On paddy the average increase on ryots' lands was about 30 per cent over the yield of unmanured lands. It is found to act much more quickly than farmyard manure.

The most recent information is from a Gōdāvari ryoṭ who, in 1920, used 3 cwt. fish manure and 1 cwt. bone meal per acre of paddy, and obtained 255 "kunchams" per acre as against a customary and neighbouring yield of 50 kunchams, being a five-fold increase.

As regards the price of nitrogen, it is stated in the notes that a unit (22·4 lb.) in fish guano costs Rs. 10–11–5 to Rs. 12–13–9 (according to the heavy fluctuations of recent years), as compared with Rs. 16–8–10 to Rs. 25 per unit (recently) in ammonium sulphate and Rs. 22–8–0 to Rs. 23–5–4 in sodium and calcium nitrate, while its phosphoric acid worked out at Rs. 2–8–0 per unit as compared with the same cost in bone meal and flour phosphate, and Rs. 8 in superphosphate.

The purchases by the Department of Agriculture, mainly for sale to ryots, aggregated 2,403 tons of fish guano and 167 tons of fish manure in the past three years, while the disposal amounted to 1,911 and 142 tons, respectively. But for the shortage and consequent high prices in 1920–21 this would have been greatly exceeded, since fish guano has various agricultural advantages.

87. *Cattle and poultry food.*—Fish guano or fish meal as it is called when used for cattle feeding is a good feeding stuff for cattle, pigs, and poultry, for which purpose it should contain the usual amount of nitrogen, say 8 per cent in the form of proteins, and of phosphoric acid as phosphates, and not above 5 per cent of oil. In certain fish meals from cod and fish refuse, the proteins run from 50 to 65 per cent, phosphoric acid from 6·6 to 13·1 per

cent, and fat from 1 to 6 per cent; but herring meal while showing 60 to 70 per cent of proteins was deficient in phosphoric acid (3·6 to 4·6), and showed a large excess, 10 to 12 per cent of oil. The samples from the Tanur yard as analysed at the Imperial Institute averaged 8·5 per cent of nitrogen (53 per cent of proteins), 8·6 per cent of phosphoric acid, and 6·8 per cent of fat. It has not been found possible to experiment with fish meal in this country, but dried fish (sardine) have been tried on heifers at the Agricultural College, Coimbatore; an account of this experiment will be found in the Agricultural Journal of India, October 1914.

88. *Price.*—The price of guano in the United States of America was in 1912 (pre-war) 30 dollars or Rs. 90, at the exchange of 1*s.* 4*d.* per rupee, per United States of America ton of 2,000 lb. Stevenson mentions 24 and 26 dollars (Rs. 72 and Rs. 78) per ton: these figures give approximately Rs. 100, 81, and 88 per British ton. Post-war prices are far higher. In the Madras Presidency the rates have fluctuated and do fluctuate immensely owing to war conditions and the operation of supply and demand. In 1910-11 the price was normal, based approximately on manurial values, and ran about Rs. 70 per ton; this was fair at then prices of fish, labour, fuel, etc. During the war when export was difficult or impossible, quantities were offered—without buyers—as low as Rs. 30 and Rs. 35, but have since been far higher. In any given year it is usual for prices to run fairly low (Rs. 75 to Rs. 90) in the early part of the manufacturing season (September, etc.) when manufacturers wish to get rid of old stock in preparation for new manufacture, but as the demands then come in from planters, exporters, the Agricultural Department, etc., and possibly conditions appear unfavourable (e.g., absence of shoals, want of oil in the fish, etc.) prices may run up to, say, Rs. 120.

At Rs. 96 per ton the nitrogen at 8 per cent average may be taken as fetching Rs. 10 per unit, leaving Rs. 16 for phosphoric acid at Rs. 2 per unit. This may be compared with the prices of nitrogen and phosphoric acid in other fertilizers such as oil cakes, inorganic (chemical) substances, etc. (see paragraph 86 supra).

89. *Economics of guano manufacture.*—In the United States it is considered an economic crime, legally punishable, to convert edible fish into fertilizer; the Coastal States usually provide penalties in their laws, and in Virginia the law provides that any one netting for such manufacture a catch containing more than

1 per cent of edible fish shall "immediately open the net and turn loose such food fish while yet alive," though herring caught in pound nets may be used for the purpose; moreover, any one having in possession more than 1 per cent of food-fish among menhaden caught for the purpose of manufacturing guano and oil, shall be fined not less than 1,000 or more than 3,000 dollars (Rs. 3,000 and Rs. 9,000), and shall suffer revocation of his licence for the season; the licence, by the way, costs 100 dollars (Rs. 300) per annum in all States.

On this point paragraph 6 from the Madras Fisheries Annual Report for 1913-14 is relevant:—

"It may here be well to mention a point of importance, viz., the apparent economic sin of turning these fish, so valuable as food, into a soil fertilizer. At first sight it seems wrong (and the sentiment has been reflected in previous reports) that good nourishing human food should be turned into manure. But there are considerations which, especially in the tropics, put a different complexion on the matter: (1), that with the present means at disposal, or at all events under indigenous methods of curing, the masses of sardine which are sometimes caught in vast quantities within a few hours, cannot be turned into safe and wholesome food (especially when the fish is very oily) owing to the rapidity of tainting and the paucity of labour, so that the turning of the fish into fertilizer either as guano or as dried fish manure, is a necessity; (2) that when the fish is not oily it is of inferior value as food; (3) that when fish is deprived of its oil (itself a very valuable commodity) or is non-oily, the residue or mass if skilfully applied as a soil fertilizer, produces more human nutriment in the shape of cereals, etc., than if it were consumed directly, as fish. Hence the method of reducing fat fish to oil and guano, or the lean fish to ordinary manure, does not necessarily deprive the country of food, but increases the total supply and yields an economic and industrial gain."

OILS.

90. *Quantity and yield.*—As regards menhaden oil in the United States the yield has been mentioned above, paragraphs 8 and 37; on a collation of all available figures the average percentage yield on all parts of the coast and over a long series of years taken together, amounts to about 5 per cent on the weight of the fresh fish, it being very noteworthy that by far the larger percentages are on the northern coasts and the smaller in the tropical and subtropical waters of Virginia, Carolina, etc. Moreover, the annual

aggregate yields vary greatly in actual quantity; in the ten years 1889 to 1898 the yield varied from 3,327,030 gallons maximum to 1,329,644 gallons minimum; in 1910 the production was 70,000 barrels, while in 1911 it was 135,000 barrels: the differences are due partly to fluctuations in the number of fish caught, partly to variations in the percentage of oil.

These facts are of great importance in considering the yield of sardine oil on the West Coast and consequent profit to the industry and its value as a trade. It is to be remembered that Madras West Coast waters are *wholly* tropical so that on the analogy of the United States the average Madras yields of oil should be very low; this would undoubtedly be the case but for the enormous amounts of food brought down in the south-west monsoon (June to September) by the high floods in the coastal rivers; the sardines usually fatten tremendously on this food, and it is for several months after the monsoon that the fish are at their fattest. Whether there is a direct connexion between the character of the monsoon and the fatness of the fish has not been seriously examined. But another factor seems to be of importance, viz., the age of the fish; it is the adult fish which give the maximum amount of fat, and it was from these, averaging 25,000 to 40,000 to the ton, that the heavy yields in 1910-11 were obtained at Cannanore and the neighbourhood. For most of the subsequent years the average size of the fish has greatly decreased; e.g., the bulk of the catches in Malabar have lately been running at from 70,000 to 90,000 or more per ton; these are all small and very lean, immature fish which produce, at any season, a minimum of oil; see the remarks in the several annual reports recorded in Fisheries Bulletin X and for subsequent years, both as to scarcity and leanness of the fish. Mature fish, frequent shoals, a heavy monsoon, and localities in which, as in the bay below Mount Dilli (just north of Cannanore) and in other similar localities, the fish find sheltered feeding, seem to be important factors in the yield of oil. South Kanara appears to be more productive both of fish and oil than Malabar.

91. In the reports for 1909-10 and 1910-11, the facts found at Cannanore where experiment began, appeared to warrant in good years an expectation of 20 per cent guano and 10 per cent oil, the latter outturn being well below the percentage obtained in 1910-11, viz., 15 per cent; the remarks were, however, expressly limited to that particular season, and the following seasons showed that the

hope was unwarranted. Doubtless the high profits of the first two or three years led to the rapid development of the petty factories, but the continued increase of the same to the present time shows that good profits are, in general obtainable, whether from guano alone or from the combined output of oil and guano.

92. *Quantities.*—The quantities of oil produced over a series of years are not accurately known since no statistical staff exists ; the proportions of oil to fish are very fluctuating, and the factory owners are suspicious and reticent in view of income-tax possibilities. But it is obvious that a good deal of oil, possibly above 5,000 tons, is obtained in years when, as in 1919-20, at least 100,000 tons of fish were utilized in making 20,000 tons of guano ; on the other hand oil may be scarce in adverse years. For instance, during the very adverse current season, 1920-21, the gross output of oil is estimated at less than 400 tons from possibly 10,000 tons fresh fish (2,000 tons dry guano), or less than 4 per cent ; the *maximum* yield was said to be 5 per cent.

93. *Character of the oil.*—Menhaden oil is described in paragraphs 4, and 38—41 supra ; West Coast oil is mentioned in paragraphs 4, 57—59, 64 and elsewhere. Generally speaking, the oil now produced at the Government yard, Tanur, is of fine quality ranging from light yellow to orange and never deeper in colour, and corresponds to that produced by the best American methods ; the best oil has been described by a firm in England as " unique " ; it is almost inodorous and comparatively tasteless and free from acidity. But the oil generally produced by the small factories is very different, being always brown, sometimes almost black from scorching (see paragraphs 57—59): it is stronger in odour than the Tanur oil, sometimes being malodorous, and from want of washing and from exposure to air it is frequently unduly acid. There are exceptions where certain manufacturers have accepted teaching by " Fisheries " ; in such cases, even where steam is not available, A-1 yellow oil fit for any purpose, has been produced in considerable quantity. The following extract from the Bulletin of the Imperial Institute, London, for January—March 1914, relates to samples sent home for examination ; specimens 6, 7, 9 and 10 were samples of ordinary coast oil, the others being from the Tanur Yard. It must be noticed, however, that all these samples were sent in the earlier days of manufacture, and that the ordinary coast oil when made by the better class of factories is now probably better than samples 6, 7, 9 and 10.

"Seven samples of sardine oil and one sample of stearin obtained from sardine oil were received in August 1912. They were as follows :—

(1) "Palest oil from Cannanore"—a pale yellow oil which deposited stearin on standing.

(2) "Palest oil without stearin"—This was a bright yellow oil, clear when received at the Imperial Institute, but like but other samples designated "oils without stearin" (Nos. 4 and 6), it deposited stearin to some extent at the temperatures commonly prevailing in Europe, viz., up to 20° C.

(3) "Palest oil with stearin"—a yellow oil with a deposit of stearin.

(4) "Yellow oil without stearin"—a pale brown oil.

(5) "Yellow oil with stearin"—a pale brown, viscous oil.

(6) "Brown oil without stearin"—thick brown oil possessing an unpleasant odour.

(7) "Brown oil with stearin"—dark brown semi-solid oil, possessing an unpleasant odour.

(8) "Stearin"—pale brown, soft fat.

The samples were examined with the results shown in the following table ; No. 7 contained about 3·2 per cent of water, which was removed before the constants were determined :—

	No. 1.	No. 2.	No. 3.	No. 4.	No 5.	No. 6.	No. 7.	No. 8.
Specific gravity at 100° C / 15° C	0·878	0·877	0·877	0·877	0·876	0·876	0·875	0·874
Acid value *	3·7	2·3	1·8	4·7	7·1	35·0	53·5	9·0
Saponification value * ...	196	194	194	193	198	199	200	198
Iodine value per cent ..	154	156	157	159	154	157	157	151

* Milligrams of potassium hydroxide per gram of oil.

The general characters and constants of these sardine oils indicate their suitability for the usual purposes to which fish oils are applied, viz., leather dressing and currying, and to a smaller extent for soft soap manufacture, tempering steel, admixture with paint oils, and jute batching. The stearin would also be suitable for use in leather manufacture and soap making.

The various fish oils used in commerce (e.g., cod, herring, menhaden Japanese sardine and shark liver oils) differ a good deal from one another, in physical and chemical characteristics, but they all have a high iodine

value. This constant is of great importance as it indicates the readiness with which an oil will undergo oxidation, a property on which the value of an oil for leather dressing largely depends.

The principal fish oil used in the leather industry of the United Kingdom is cod oil, commercial specimens of which usually have an iodine value of about 155. It will be noticed that the iodine values of these sardine oils from Madras, viz., 154 to 159, approximate very closely to this figure.

With the exception of the brown oils Nos. 6 and 7, all the samples had low acid values and appeared to have been carefully prepared. The somewhat high acid values of the brown oils would reduce their value for leather dressing, as such oils are usually regarded as unsatisfactory for this purpose.

Two further samples of fish oil were submitted for examination in February 1913:—

No. 10. "Brown oil without stearin."

These oils were dark brown in colour and had a very unpleasant odour. They were filtered, and then chemically examined with the following results:—

	Brown oil with stearine.	Brown oil without stearine.
Specific gravity at $\frac{100° C.}{15.5° C.}$ ...	0·881	0·879
Acid value	12·1	11·8
Saponification value (approx.) ...	200·2	200·0
Iodine value per cent	155·2	154·1

The constants of these two oils correspond on the whole with those of the previous samples.

The present specimens have much lower acid values than the two samples of brown oil (Nos. 6 and 7) then dealt with, but they were darker in colour and their odour was still more unpleasant.

The remarks made above as to the uses of the oils are also applicable to the present samples."

The stearine mentioned in this extract (see also paragraph 39) is the "fish tallow" deposited by the fish oil in considerable quantity, probably amounting to some 25 to 33 per cent of the whole oil. It is not understood why the words "pale brown" are used for samples 4, 5 and 8, since they were yellow when sent and apparently so when seen in 1914 at the Institute.

94. The following characteristics of menhaden, of Japanese sardine and herring oils, and of Malabar sardine oil, may be useful for reference and comparison, and as guides in practical work :—

Oil.	Specific gravity at 15·5 C. 60° F.	Saponification value.	Iodine value.	Acid value.	Remarks.
Menhaden ...	·931	193	160 150—170	7	Taken from Lewkowitsch and Fryer and Weston (Cambridge Technical Hand-book of oils, etc.) and, for Tanur oil, from the Bulletin of the Imperial Institute for Jan.—March 1914.
Japanese sardine.	·933	195	181—187	10—34	
Japanese sardine herring.	·921	188	...	...	
Japanese Commercial fish oils.	·925	191	..	10—40	
Madras (Malabar) sardine oil.	·88	196	156	3 - 9 12 - 53	

Specific gravity is remarkably low in the Malabar oil.

"Saponification value" represents the number of milligrams of potassium hydroxide (caustic potash) required to saponify one gram of oil: this is of importance in soap making.

The "iodine value" is of great technical importance: to a great extent it indicates the drying character of the oil and its suitability or otherwise for lubricating and burning: a high iodine value is unsuitable for edible oils and usually means a strong flavour, and so on. Fish oils are of high iodine value, being only surpassed (among ordinary oils) by linseed, the best of drying oils; olive, cotton seed, gingelly, and ground-nut oils range between 80 and 110; palm, mowah and iluppai between 55 and 65; and butter fat is as low as 35. The fish oils as shown above range from 156 to 187, but it is stated that yellow Japanese fish oil may be as low as 100 (Lewkowitsch).

The "acid value", i.e., the amount of free fatty acids as shown by the number of milligrams of potassium hydroxide necessary to render the oil neutral, is of much importance, since it indicates the degree of decomposition of the glyceride, that is, the whole oil, into glycerine and free fatty acids. "If oils and fats are left in contact with putrescible or fermentible matter, the amount of free fatty acids may rapidly increase and rise to 70 or even to 100 per cent as in the case of old palm oil. The importance of the acid value lies, therefore, in the fact that it indicates the *quality* of an

oil or fat " (Lewkowitsch). Seeing that fish oils contain when absolutely fresh and properly prepared, practically no fatty acids, the acidity of a fish oil is good evidence as to its proper or improper preparation, purification, and storage.

Acid oils are unfit for use as edible or medicinal oils if the acidity is marked, say, above 5 per cent, owing to the sharpness of their taste, and also to the effect on the mucous membrane, as may be noticed in the usual test, by taste, when an acid oil produces a catching of the throat; they are equally unsuitable as lubricants owing to the action of the acids on metals. It is probable also that acid oils actually contain less glycerine than normal, since the glycerine separated by the decomposition may have been lost in washing the oil. For soap-making acid oils are not unsuitable since free fatty acids are more easily saponified than neutral oils; they are said however to have a higher saponification value. Acidity is easily removed, however, with some loss and expense; see below *s.v.* "*Refining.*"

The varying acidity in the above table is probably due to careless preparation and storage; being usually prepared in primitive fashion by persons of small knowledge and capital, the oils, as shown elsewhere, rapidly develop acidity; see especially paragraphs 59, 71, 93, 107, 112, 115, 119, 123, 126.

95. *Uses.*—The uses of fish oil have been mentioned in paragraph 4 supra, and in the extract in paragraph 93, to which may be added the following extract from the Imperial Institute Bulletin for April—June 1914, pages 259–260.

"The use of menhaden oil for paint appears to be on the increase in the United States, and according to Toch (Journ. Indust. and Eng. Chem., 1911, 3,627), it is the best fish oil for this purpose, as up to 75 per cent it can be used in admixture with linseed oil, the paint still standing exposure to air well. Its use for painting interiors of buildings is not advisable on account of the unpleasant smell. It is also claimed that paint made with menhaden oil is more resistant to heat than linseed oil paint, and is therefore suitable for use on boilers and chimneys. It can also be used in printing ink manufacture, and according to Toch (*loc. cit.*) it is more flexible and less liable to crack than linseed oil, so that it can be used for patent leather manufacture, although it produces a peculiar efflorescence when used for this purpose. The most suitable 'drier' for use with menhaden oil paints is stated to be a tungate drier."

Tungate driers are salts of lead and manganese prepared with the fatty acids from tung oil.

But adverse opinions are also expressed as to the use of fish oils in paints, as they are not really in the class of true drying oils, and it is said that they do not, when oxidized, dry to an elastic skin as is the case with linseed oil. Hence for use in paints their drying quality should be above the ordinary, and the proportion should not exceed about one-fourth of the linseed oil.

Other uses are mentioned such as its employment in the manufacture of linoleum, and in rubber substitutes, and in making waterproof solutions, while it is said to be highly useful for "patent" leathers since, though not quite so glossy as when prepared from linseed oil, it is more flexible and less liable to crack. West Coast fish oil is believed to be used in a wellknown Madras waterproofing method. Under the head of "stearine" other uses are mentioned for this grease.

It need only be added here that the Tanur oil has been found satisfactory in leather work at Cawnpore, in Arsenals for browning rifle barrels and stocks, and in the Madras Arsenal during the war for making harness and leather "dubbin." It has also been largely used by the Government Soap Expert at Calicut in making insecticidal soap of good quality and efficacy in spraying coffee, mango trees, etc., for the destruction of pests, while the "saddle soap" has been highly commended by military officers. A good deal of the finest yellow oil has been taken by medical officers for use in wasting diseases as a substitute for cod liver oil, but is, apparently, of less efficacy in tuberculosis; its congener, pilchard oil, is considered a panacea in Cornwall, and this high class sardine oil seems worthy of extended and organized trial; it is believed that one firm advertises a special quality for medicinal purposes.

The finest A-1 quality of specially prepared sardine oil has also been used as an edible, viz., in frying sardines in the Government Cannery at Chaliyam and as a part of the oil used in actually packing the sardines in tins; such oil adds richness to the fish, being derived from similar fish; it also cancels the specific flavour of groundnut oil used in such packing, as has been noted in mixtures of other oils, e.g., cotton seed oil with groundnut, etc. But only absolutely first-class sardine oil can be so used; see Bulletin on Canning. In Japan sardine oil is habitually used in domestic cooking.

96. *Hydrogenation.*—Some of the fine Tanur oil was submitted to hydrogenation and the resulting hard, white fats are of excellent

quality; the text-books and technical journals also report that full hydrogenation removes the odour, taste, and most of the colour of common fish oils. It is probable that such oil, if properly prepared in the highest classes by the coastal factories, might have a good market for hardening purposes in the production of edible fats, while the ordinary oil generally could be hardened for technical purposes, e.g., to take the place of tallow in soap making.

This indicates one more important reason, apart from mere price, for vending effort towards the manufacture of good class oil rather than low class, nauseous oil; oil of good initial character, free from acidity, would be a cheap and excellent basis for hydrogenation. For instance, it is obvious that if fish oils average £12 per ton and the hydrogenation process costs much as £8 (£5 is mentioned in Europe and America), such hardened oil would compete very favourably with ordinary tallow at £35 per ton.

Refuse stearine and oil has been utilized in making lamp black but the manufacture has not been developed.

97. *Prices.*—The prices of menhaden oil are noted in paragraph 42 supra. According to the Imperial Institute Bulletin of April—June 1914, the price in 1913 was about 1*s.* 2*d.* for crude and 1*s.* 6*d.* for "white bleached Winter" oil. But in 1919 the prices were at and above 3*s.* 4*d.* and 4*s.* 2*d.* respectively, or, with the rupee at 1*s.* 4*d.* as at present (April 1921) Rs. 2-8-0 and Rs. 3-2-0 per United States gallon of about 7¾ lb. oil.

On the West Coast the market price as originally obtained was about Rs. 160 per ton of 250 gallons or slightly over 10 annas per gallon of crude oil-cum-stearine. Since that time it has greatly fluctuated owing mainly to war conditions; prices in recent seasons have been subject to wide fluctuations: at one time in 1919, ordinary brown oil was unsaleable at Rs. 75 per ton or below 5 annas per gallon. During the season 1920-21 it is stated that the prices ex factory were as low as Rs. 100 to Rs. 125, but no reason is assigned for this slump in price. It is true that no superior oils were made or demanded, but such oils were never made in such quantity as seriously to affect the average level of prices; possibly the want of demand for guano (paragraph 79) may have led to carelessness in the manufacture of oil, with the result of an inferior article.

Effluent Water.

98. This is not a commercial but a technical product, the utilization of which is a matter of difficulty, while if not utilized it is either wasted or is a source of nuisance. The following remarks do not apply to the waters used daily for washing out the factory, but to the waters proceeding from the fish themselves and from the boiling pans and presses.

In boiling the fish a considerable quantity of water is necessary and this, added to that in the fish tissues (about 70 per cent of the weight of the fish), means a large quantity of water issuing from the presses and receiving pits, and this water contains an appreciable quantity of organic matter especially when coarse-meshed coir bags are used. Owing to the organic contents (albuminous, gluey), etc., this effluent water, even when fresh, possesses a somewhat unpleasant odour, and when stale rapidly becomes a nuisance owing to putrefaction. In most factories the water is sent straight into the sea ; in America the factories are either on the shore or even built out over the water, so that the effluent water and useless refuse are readily and safely disposed of. On the Madras West Coast nearly all factories are on the edge of the beach and the water is, or should be, easily sent into the sea. But it is not uncommon, especially when the sea has receded (as at Tanur) or the monsoon has flung up sand ridges, for the water to be passed into the deep sand of the beach where it putrifies and causes a serious nuisance, not necessarily, or even probably, dangerous to health but objectionable from its foul odour. But the very cause of the nuisance, viz., the presence of organic matter, shows that the water may be a by-product of some value and should, if possible, be utilized. In America it is reported (R. L. Greer) that a considerable amount of sediment collects at the bottom of various separating tanks, especially of the "catch-all" tanks into which all effluent waters are sometimes run for the saving of any oil or material. The solid sediment, called "gurry," is removed, pressed, and the cake added to the general mass of guano ; the water is run into the sea. But in one factory (perhaps in several according to other information) it has been found possible to evaporate the "stick-water" (effluent water) till a pasty residue ("stick") is obtained which contains about 9 per cent of ammonia (=7·4 per cent nitrogen). Whether the evaporation of such a mass of water gives *profitable* results seems doubtful though it

may have been found necessary for sanitary reasons. Here in India, even with a powerful sun as an accessory, it would be impossible; very expensive plant is needed, fuel is dear, the factories are minute, and the fluid rapidly putrefactive even though disinfectants are used.

99. The proper use of the effluent water appears to be in irrigating fruit trees (coconuts, etc.) or field crops; it is economically wrong—unless sanitarily necessary—to pour useful manurial water into the sea, and sanitarily wrong to let it stagnate in the sand. In one factory the water was taken by a coconut owner who considered it profitable to send large boats for the fluid, while it is certain that coconuts bordering the Tanur yard developed abnormally by its aid. But the matter has never been studied, although comparative experiments were started at Tanur. In the small quantities applied to each tree no nuisance is perceptible if the sand round the trees is properly handled; moreover since it is an objection that surface watering is inimical to the trees as tending to mere surface growth of roots, it is quite possible to remove both this objection and any sanitary objection by inserting a couple of 2″ drain pipes, of ordinary porous material, vertically in the soil three feet or so from the tree and on opposite sides of it, so that the water passes at once below the surface and the sun's action, and penetrates deeply into the sub-soil; this is also economical of water in ordinary tree irrigation. In this way a potential nuisance can be avoided and turned into an economic benefit.

100. It is suggested that the following procedure may be adopted where it is sought to utilize the effluent water or where, if it *cannot* be sent into the sea, it might otherwise be a nuisance. Receive all such water in a masonry tank of which there should be two, each sufficient for the receipt of the whole effluent water from a day's working, so that while one is under treatment as below the other may receive the current day's outflow. Treat the fluid with a sufficiency of lime in powder, taking care to sprinkle the powder in successive portions on to the surface; this will temporarily deodorize the fluid and at the same time precipitate solid impurities as a sludge or sediment; the supernatant fluid can then be baled or carried to any available coconuts as at Tanur yard. The calcareous sludge at the bottom of the tank can then be removed and dried with very little annoyance.

If chloride of lime (bleaching powder) is available, a small quantity added to the tank fluid and to the sludge will prevent all nuisance while not affecting the value of the fluid to the trees, especially if a corresponding amount of soda ash (sodium carbonate) be added, in which case sodium hypochlorite will be formed which will entirely deodorize the fluid and, *in so doing*, be converted to sodium chloride (*common salt*) which is beneficial to coconuts.

If the supernatant fluid is first passed through a filter, it would probably be wholly inoffensive when used for irrigation, since, as shown below under "septic tanks," the operation of the filter is to bring nitrogenous matters into innocuous forms. Such filter is preferably an open masonry tank, sunk in the ground, and may be of any area convenient for the quantity of water to be filtered, and about 6 feet deep. A perforated false bottom is placed about 1 foot above the true bottom, and over this a mass of hard cinders, broken coke, broken brick, etc., not larger than will pass a two-inches ring. The fluid from the depositing tank should be baled or pumped into this tank through a pipe entering the filter below the false bottom, so that the fluid may pass upwards through the filter and flow off from the surface into a cistern whence it can be readily baled, etc., to the trees. In this way it would be easy to avoid all real nuisance and at the same time to utilize the waste waters profitably.

If trees or crops are not available for utilizing the treated water, it must, after treatment as above, be sent into deep sand pits which should be daily covered over with fresh sand.

101. An alternative plan is to establish "septic" tanks. These "tanks" take advantage of bacterial action to break up organic matters, such as are contained in excreta, tanners' "waste," distillery and brewery waste fluids, etc., and thereby reduce them to innocuous and inoffensive forms. The bacteria required for the purpose are largely contained in the waste matters themselves, and the usual method is just to pass them into a "septic" tank which is air tight and utilizes the anaerobic bacteria which cause putrefaction; in this tank the solid matters break down and liquefy in a few hours, whence these septic (putrefactive) tanks are often called "liquefying" tanks. Thence the fluid passes to the "filter," an open tank of masonry filled with layers or masses of coke, cinders, fragments of well-burnt brick, etc., etc., as described in the preceding paragraph; here the aerobic bacteria play their

part, and with such rapidity that the effluent fluid is practically or wholly innocuous and inoffensive but still valuable as a fertiliser —See also note, page 253 infra.

The plan, dimensions, method, etc., can be obtained from books or from the Sanitary Engineer; a model which, *mutatis mutandis*, could be followed, is the small system for disposing of sewage (from the latrines, etc.) in use at the Imperial Research Institute, Bangalore.

In the case of the fish guano factories the use of lime, alum, soda ash, etc., is in any case advisable before treatment in the septic tanks, since such substances give to the fluid the alkalinity which favours the action of the bacteria and thus hastens the process; chloride of lime, however, should not be used in such case as it is inhibitive and even destructive of bacteria.

102. The due use, consistent with sanitary requirements, of these waste waters is very desirable and should be kept in view, and made the subject of careful and intelligent experiment.

STEARINE.

103. This has been mentioned as regards menhaden oil stearine in paragraph 39 supra. It is noteworthy that more stearine is found in menhaden oil from the Southern coast of the United States of America than in that from the Northern, and this is paralleled by the large amount found in Madras sardine oils. The general proportion has not been ascertained but has always been estimated at from one-fourth to one-third of the whole oil, which corresponds with the amount found in American oil. But it is to be noted that oil decanted from the stearine which is perfectly clear at Madras temperatures, deposits further amounts when taken, say to London: exhibits of perfectly clear oil sent to the Imperial Institute, Kensington, were very disappointing in appearance.

Apparently the stearine is obtained in quantity because of the high temperature (boiling) at which the oil is prepared; for when fat fish are heavily salted and kept in masses in receptacles (pilchardised) at ordinary temperatures, the oil which is skimmed from the surface or expressed by pressure with screws in barrels, is practically free from stearine, though of a rich, dark, brownish red colour. This is also the case with pilchard oil in Cornwall where this practice is in vogue and whence it was copied (see Bulletin on Fish-curing); pilchard oil is, or was, considered in

Cornwall to be a medicinal panacea. Apparently sardines (and pilchards) contain solid fats which do not become fluid unless heated beyond even tropical day temperatures.

Stearine has a stronger and more persistent odour than the oil, but in general is not separated from any oil except from the finer qualities, as it melts at a comparatively low temperature and therefore serves as well as the oil in such operations as steel tempering, jute batching, etc., and the oil is generally sold just as it is produced, without any special separation or refinement, as oil-cum-stearine: no objection is raised on the ground of its stearine contents.

The word "stearine" is apt to mislead, since the substance contains little or no stearic acid; in fact fish stearine is said to consist mostly of palmitin; however, if neutral, it should prove very valuable for hydrogenation into a tallow suitable for technical purposes such as soap making.

The only method hitherto adopted on the West Coast for separating the stearine has been by settling and decantation, a very crude method, since much of the oil remains entangled in the stearine and, as mentioned above, in cooler climates, oil clear in Madras deposits further stearine. The absence of a winter or of a temperature below, say 70° F., and of artificial refrigeration, entirely prevents the preparation of "winter oil" by the means mentioned in paragraph 39. An experiment with a small filter press was unsuccessful, as no means of cooling the oil were available. If perfectly clear "winter oil" is required for medicinal or special (edible) purposes, further experiment with cooled oil, a proper filtering medium, and suitable apparatus will be necessary; the matter is further dealt with in the paragraphs on "*refinement.*"

104. Fish tallow is also much used in preparing lubricating greases, sod-oil (dégras), dégras substitutes, stuffing greases, etc. (Lewkowitsch). In the United States of America menhaden oil is the oil used in chamoising skins and in the consequent preparation of the resulting "sod-oil" (dégras) which is used in currying or dressing bark-tanned or chrome-tanned leather; and in general commerce artificial (factitious) dégras prepared from "menhaden, sardine, Japan fish oils, fish stearines, etc.," are found as substitutes for the genuine dégras: the artificial substitutes are made by blowing air through the fish oil (or melted stearine), so as to imitate the natural oxidation of the genuine process. But it would seem that there may be some bacterial action in addition to simple oxidation.

Stuffing greases are those used for giving suppleness to tanned leather while at the same time rendering it water-proof and increasing its weight; fish tallow is a regular ingredient of such greases.

There should be considerable use for West Coast fish stearine, even in India, for waggon greases and in leather working.

MANUFACTURING PRECAUTIONS.

105. Before discussing the modes of refining fish oil, it is necessary, even at the cost of some repetition, to mention the evils to which fish oil is subject; then only is it possible to differentiate good from inferior oils, to understand why certain things should or should not be done, why certain methods should be adopted or avoided, why certain precautions should be taken, how certain impurities or deteriorating agencies may be minimized or removed, how such methods and precautions will greatly add to the value even of crude unrefined oils, and may often obviate the need for subsequent refining which always adds some expense in labour, loss of oil, etc., and indeed, in the case of really bad oil, may even be impracticable.

106. *Characteristics of fish oil.*—Good fish oil should be bright and clear, from pale yellow to brown in colour, of an odour which, though fishy, is moderate in character, like that of good cod liver oil, and of similar taste. Inferior oil is turbid, dark brown to black in colour, of strong and even nauseous odour often including that of taint or of scorching, and of pungent and very disagreeable flavour; if acid, it is not only sharp to the palate but is very irritant to the throat owing to the action of the fatty acids on the mucous membrane. While high quality fish oils are suitable for edible and medicinal purposes, low class can only be used for rough industrial purposes such as the tempering of steel, etc. Prices of course vary with quality; when common oil was quoted (pre-war) at £14 to £16 per ton, fine yellow oil from Tanur was priced at £18 to £21 in the English market.

107. Fish oil—like other oils—is a glyceride of the fatty acids, that is, it is a combination of glycerol with certain fatty acids, which differ greatly according to the source of the oil. These constituents of oil may be separated one from the other by decomposition; mostly by what is called hydrolysis or the action of water on oil, assisted by various agencies such as bacteria, enzymes, organic impurities, warmth, light, and air. Oil thus decomposed is

thereby deteriorated in a degree which varies largely with the stage of decomposition and the character of the fatty acids, as will be mentioned below. Hence even originally good oil, if subsequently treated improperly, may deteriorate and lose much of its value.

But much of the oil found in Indian commerce is not good oil from the beginning, but is crude, dirty, and already partially hydrolysed; this is due to the imperfect conditions under which it is obtained, viz., primitive method, simple and even crude plant, and dirty surroundings; consequently it is largely of poor colour, acid, rancid, full of impurities such as dirty water, mucilaginous and albuminous substances, and so on. Fish oil is especially liable to these evils which, moreover, result in characteristics far more unpleasant than in the case of vegetable oils, owing to the sources from which it is derived, the method by which it is or used to be obtained, and the malodorous character of its fatty acids at all events when rancidity has set in. Hence fish oil is apt to have a bad name in the market as a repulsive product, and it has been the object of the Fisheries Department to improve it so that it shall take better rank, subserve more and better uses, and obtain better prices than ordinary crude fish oil; it is also the object of this bulletin to assist in this improvement.

108. Fish oil, then, is derived from marine animal sources; excluding sperm oil, it is obtained mostly from the general tissues such as sardine and herring oil, in which case it is called "body oil" or fish oil proper as distinguished from "liver oil" which is derived from the livers of various fish, such as the cod, shark,* etc. In this bulletin only body oil, viz., that the oil sardine (nalla matti, *Clupea longiceps*) is dealt with.

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* It is curious that whereas in the cold waters of temperate climates fish oil is so largely obtained from the *livers* of fish, e.g., of the cod which contains no oil in its tissues, in the tropical waters washing the Indian coasts the oil is mostly in the tissues; not merely in the case of the oil sardine, but of the seer (*Cybium commersonii*), varian, etc. This is a serious matter in curing fish by sun-drying; whereas cod, haddock, hake, etc., when salted and dried present a white, clean, and even silvery appearance, Indian dry salt fish is brown or yellowish brown of uneven colour, owing to the discolouration (oxidation) of the oil which exudes from the cut tissues—when the fish is split and opened out—and lies on the surface exposed to the sun and air. Such fish is preferred by Indian consumers, doubtless from their experience that such fish are fat and consequently *pro tanto* nourishing, whereas colourless fish are evidently not fat; on the other hand European consumers would not look at Indian discoloured fish.

109. *Avoidance of taint.*—Since fish tissues, especially in tropical climates and under the faulty conditions of capture which generally prevail, taint within a very few hours, and since the oil is derived from such tissues, it is obvious that if the oil is to be free from the putrid odour of taint, not only must the fish itself be free from taint, but the oil must be separated with the greatest possible expedition from the tissues which begin to decompose *immediately* life is extinct; otherwise not only will the oil be malodorous from the beginning but it will contain agencies which at once proceed to decompose the oil itself. Hence the ancient Indian method—found in primitive practice all over the world at one time or other—of obtaining the oil by allowing the mass of sardine, contained in an old canoe or other receptacle, to putrify till the oil, aided by a little water, came to the surface of the semi-liquid mass, necessarily produced a nauseous oil, horrible in odour and taste and colour. The newer method is that of boiling the fish on receipt, and of skimming and expressing the oil forthwith; but it is obvious that even by this method the fish must not be allowed to taint and the oil must be separated at once; otherwise the former evil, in less degree, would arise.

110. The nauseous character and in part, the bad colour, of oil from tainted fish is due to the decomposition of the tissues of the fish and especially of the proteid or nitrogenous matter; the decomposition products of these matters are very malodorous, discoloured, and even poisonous, and these products largely pass out with the oil when it is removed from the mass by boiling and pressure.

Now it is very difficult and costly to remove these objectionable products from the oil; authorities, indeed, say that it cannot be done on a commercial basis if the oil has been obtained from putrid material. Hence it is of the first importance, if fish oil is to take a good place and obtain a good price, that by all means possible the oil should be obtained from fresh fish in which taint has been prevented or at least inhibited.

It may be added that, in the matter of the guano also, this is important, for putridity means loss of nitrogen in proportion to the degree of taint, the nitrogen being lost as ammonia or passing away in the putrid fluid which exudes from the fish; since nitrogen is by far the most valuable constituent of the guano, such loss means loss of value and consequent loss of price.

111. Hence the *first point* to be attended to in obtaining fish oil (and guano) is the avoidance of taint in the fish whether by insisting on freshness or by the use of a preservative such as salt. To this end (and for sanitary reasons and to avoid public nuisance) factories should make arrangements, if possible, that *the fish should be brought to shore as soon as caught, e.g., by carriers*, and at once dealt with ; this conduces also to efficiency and superiority of product since it distributes the work over a longer period and does not crowd operations or tire workers. Moreover, factories should not attempt to deal with larger quantities than can be worked off in, say, 12 hours ; further, it is strongly advisable that the latest received batches should be mixed with salt, say 1 lb. of salt to 16 lb. of fish, to inhibit taint while waiting. If the fish are to be kept any further length of time, a larger proportion of salt, say 1 to 12 or even 1 to 8 should be used when they will keep fairly well for a short time, but not for long since they are ungutted. The presence of salt is otherwise advantageous, since oil separates more rapidly from salt water of specific gravity greater than that of pure water.

112. *Rapid separation of oil from the fish.*—The *second point* to be mentioned is the advisability of rapid separation of the oil from the mass of fish ; by long heating in contact with the tissues, or by leaving the oil for a few hours in contact with the boiled mass, the oil not merely darkens in colour but, which is more important, absorbs or takes up proteid and other matters which are foreign to the oil and will rapidly decompose in the oil, thus producing not only the malodorous decomposition products above mentioned but assisting the water in the oil to decompose (hydrolyse) the oil itself, thus producing acidity and rancidity.

If fat fish are boiled with a considerable quantity of water so that the oil may come rapidly to the surface, the oil on first appearance, a few minutes after beginning operations, is so limpid and colourless as to be observed with difficulty; a little later it becomes yellow; if then skimmed or run off with the surface water, at once separated from the water, and then washed with boiling water, preferably saline, the resulting oil is A 1, ordinarily needs no further refining, has been described as "unique," and is fit for and has often been used for edible and medicinal purposes; it may however be rendered softer and more bland by treatment with alkali, as shown below.

If the remaining mass after skimming, or the whole mass without skimming, is then run into draining vats, i.e., wooden or other vats with perforated false bottoms, covered with gauze or cloth, the oil obtained from the drained-off fluid is very good, of a somewhat darker yellow than the skimmed oil, but not greatly different from it if similarly treated; the difference is that it is considerably longer in contact with the boiling fish tissues, and since it drains *from the bottom* of the mass it is more contaminated with albuminous fluids and impurities.

The remaining mass is then pressed, and since the oil has now been for some time in contact with the hot mass and since there is a good deal of colouring matter in the Madras "sardine," the oil from the presses is usually darker in colour than skimmed or drained oil and, by reason of the strong pressure, a large quantity of "impurities," i.e., fluids and matter which are not oil and are usually readily decomposable, is found in the mixed oil and water which flows into the pits. At Tanur pressed oil is usually not deeper in colour than orange, so that the drained and pressed oils are generally treated together, and not being often large in quantity, they are rapidly separated and washed. But if the impure oil and water are left together for some time, e.g., *over-night*, the oil will be much darker with at least a tendency to offensive odour from the decomposition products of the impurities; this, in small tropical factories, with a small staff and no very effective means of separating the oil, is a serious cause of inferior, highly odorous, dark oils.

113. Hence it is important to use means to separate the oil from the fish mass with the greatest possible rapidity; this is one main reason for the general use in the United States of America of continous operations in which the fish pass in a regulated stream through a steam cooker in the form of a lengthy cylinder traversed by an archimedean screw or conveyor, in which they are kept under the continuous action of steam; from this cooker the cooked mass is taken by a conveyor and dropped into a continuous press in the form of a conoid or tapering cylinder also traversed by a screw which forces the mass into a gradually contracting space and thus squeezes out the oil and water: the operation takes, for each fish, not many minutes from the entrance hopper of the cooker to exit as "scrap" from the press.

On the West Coast the manufacturers in general, under a mistaken idea of economy, cram large boiling pans with much fish

and little water, the pans being usually badly heated by inefficient, badly designed furnaces and flues; hence the individual fish are kept for a maximum period under heat, in which some are underheated, some overheated and scorched; after a lengthy heating the fish are gradually forked out from the pan into the press bags and so to the presses; sometimes they are evacuated into pits and thence to the presses. Hence the oil is always of a dark colour and greatly contaminated with organic impurities—by quasi-solution—much of which should have remained in the guano.

In Tanur the boiling pans are mainly run by steam, the individual charges are moderate in volume, and plenty of water is used, much of which remains below the false bottom of the pans where the steam pipe lies, so that there is a boiling residuum ready for the next charge: hence rapidity, about 30 minutes, in heating each charge, this period being also utilized in skimming the oil as it rises through the water to the surface: the fluid mass is then let out through the sluice valve into the draining pit or box, whence the drained fluid passes to the receiving pit, while the mass is rapidly removed to the presses and squeezed. Even if steam is not available, improvement may be effected, as at Tanur, by having several boiling pans of moderate size, preferably copper which is a better conductor of heat, using sufficient water and employing drainage pits or boxes, with sufficient presses to press the stuff without delay; the furnaces should also be carefully designed so as to heat the pans with the maximum of speed and the minimum of fuel. The use of sufficient water in the boiling pans is important since the fish are boiled with much greater rapidity owing to the convection currents set up in the water so that the heat of the fire is transferred rapidly to the water and thence to the fish which are boiled quickly, thoroughly, and evenly; moreover when there is plenty of water the fish can be easily stirred and there is far less chance of scorching which *irremediably* discolours the oil skimming is also possible and desirable when there is plenty of water. A false bottom not only minimizes the chance of scorching by interposing a cushion of water between the bottom of the pan and the fish, but this water remains in the pan when the fish are removed, provided the sluice valve is set well above the false bottom. Moreover when in operation, the steam from this water which, owing to the superincumbent weight of fish, rises above 212° F., forces its way through the mass and thus tends to heat it rapidly and thoroughly.

114. Over an open fire a copper pan is preferable to an iron one because

(1) Copper conducts better than iron in the proportion of 10 to 7 for equal thicknesses of metal;

(2) Copper being tough, a pan, if properly supported, may be made much thinner than iron, so that conduction is still more rapid than in the above proportion; but thin pans must be supported by stays, etc., at various points or the pan would buckle;

(3) Iron pans are very apt to rust away rapidly under the influence of salt water, heat, and air, and have to be renewed; the copper pans at Tanur are 9 or 10 years old;

(4) Iron pans, especially if rusty, may discolour the oil;

(5) It is difficult to repair a hole worn in an iron boiler especially if, as is usual, the neighbouring parts have worn, whereas a patch can easily be brazed or riveted in a copper pan;

(6) When fairly worn out an iron pan is useless scrap, whereas copper can be sold at its weight value. Hence copper pans are better than iron if the first cost can be afforded.

It is recommended that steam be used if possible, but in any case that several boiling pans, preferably of copper, of moderate size and with false bottoms, be set over properly designed furnaces; that sufficient water be used to allow of skimming, or at least to permit of ready stirring, rapid and even heating, and reduction of scorching; that drainage pits be also used to assist in the rapid separation of fluid from solid, and that enough presses be supplied to work off the scrap rapidly.

115. *Rapid separation of the oil from foul water.*—The *third point*, and one of the most important, is the rapid and complete separation of the oil from the dirty water which flows from the drainage boxes and presses into the receiving pits. This requires careful explanation—with some repetition—and study, since most of the deterioration of the oil takes place after the presses have done their work; it is only when the causes of this deterioration are thoroughly understood that good oil will be the rule instead of inferior, and that the purifying and refining processes will be intelligently carried out.

Fish contain in their tissues large quantities of fluid matter which are largely proteid (nitrogenous) and readily decomposable; moreover the white fibrous connective tissue is composed of a substance called "collagen" which is albuminoid in character.

These cells and tissues are softened and ruptured by heat and pressure so that their contents pass out with the fluids as they exude from the draining boxes and presses. Moreover these proteid matters are largely soluble in water; also in oil, though the solution in such case may be only a pseudo-solution or colloidal suspension (Southcombe). Hence when even fresh fish is boiled and pressed, especially when the boiling is long and the press bags coarse, a quantity of "impurities," that is non-fatty matters, pass out in the mixed oil and water; these may be solid, viz., fragments of tissue, bone, scales, etc., whether coarse or fine; they may be large and heavy enough to fall at once to the bottom of the fluid or be retained by a strainer, or they may be so minute as to remain in suspension for a considerable period; or they may be dissolved so that even filtration is useless, or suspended as minute particles of water, or colloidal suspensions such as particles of albumen. The soluble and suspended matters are derived from the cells of the tissues, ruptured by heat or pressure, and contain some of the proteid constituents of the fish, all of which are readily decomposable and some perhaps already on that way.

When the fish is not fresh but tainted or even slightly decomposed, the action of bacteria, enzymes, etc., on the tissues, especially on the nitrogenous proteid matter, is very marked; malodorous and even poisonous decomposition products are abundantly formed which are soluble and are consequently dissolved in the water and are also taken up by the oil whether directly as colloidal suspensions or indirectly in the suspended water; in any case the contact of these products with the oil not only imparts a nauseous taste, odour, and bad colour to the oil but hydrolyses (decomposes) the oil itself so that free fatty acids are formed with the result of acidity and rancidity. The longer therefore that the foul water with its putrifying and hydrolysing contents remains in contact with the oil, the more such oil deteriorates, the worse it smells and appears, and the more difficult it is to purify and refine. Hence *it is essential*—

(1) to separate the foul water from the oil as quickly as possible;

(2) to eliminate, partly or wholly, from the oil the impurities held by the oil itself. The usual method is at best partial elimination; complete depuration means refinement which will be separately considered.

116. As shown above, in the United States of America the mixed water and oil pass into settling tanks where the solid and comparatively massive impurities specially fall to the bottom and are eventually removed and utilised as " gurry " by removal of the oil and subsequent drying of the scrap. The oil with its dissolved and suspended impurities then passes into other tanks in series where the oil and water gradually separate, the process being accelerated by raising the temperature in the tanks to 150° F. or higher, with the result—though this is not directly stated—that the albuminous matter is coagulated, since albumen coagulates at above 140° F.: the coagulated substances are precipitated and in their precipitation carry down with them suspended impurities. A further result of the steam heating when effected by open steam, is to wash the oil mechanically and, by the condensation of the steam as pure boiling water, to dissolve out from the oil any dissolved impurities seeing that these are readily soluble in hot water but sparingly soluble in oil where indeed they may be suspended rather than dissolved. Open steam heating by which fresh water is added to the oil, necessitates further separation of water, but this is part of the purifying process since the water is clear water when condensed from the steam and only becomes foul by dissolving and removing impurities; still, being rendered impure, it must also be separated as quickly as possible. The heat of the steam also tends to cause rapid separation since the specific gravity of the oil is lowered by heat to a greater degree than water. Moreover this heating, especially if carried up to ordinary boiling point, and possibly even lower, destroys any bacteria, as well as the enzymes or chemical ferments which cause hydrolysis and the formation of fatty acids and therefore rancidity. The oil thus largely purified is rapidly withdrawn from the upper parts of the settling tanks by syphons, swivel pipes, etc., and the remaining water-cum-oil is again passed into a further tank, and so on. The nature of the settling pits or tanks has been described above.

In many factories the semi-purified oil is passed through filters, whether filter presses or ordinary filters as elsewhere described *s.v.* "*filtration*"; this effectually removes any solid or coagulated impurities and with them the bulk of the agencies, which tend to act upon the oil.

117. This process is followed, *mutatis mutandis*, at Tanur, but the receiving and settling pits or metal separators are not provided

with steam heating; this would be useful. The Tanur method, after preliminary separation of the bulk of the dirty water, as detailed, is to pour the oil-cum-water into tall metal separators and then to wash the oil thoroughly with boiling water poured through perforated sieves at the top of the separators. Grain salt is also sifted in for several reasons; first, the salt grains carry down impurities entangled in the oil; secondly, proteid matters are more soluble in weak saline solutions than in fresh water, so that they are more readily dissolved by the salt water; thirdly, the specific gravity of the water is materially increased by adding salt, so that the salt solution separates more rapidly from the oil; to some extent also the salt absorbs suspended moisture from the oil as it passes through it. The separators are made tall in comparison with surface area to increase the depth and narrow the superficial area of the two fluids and thus facilitate the drawing off, by cocks at various heights, of the respective quantities. The washed oil can subsequently be heated in a special heater by a closed steam coil if so desired, in order to drive off any remaining suspended moisture, but this is not usually found necessary; the process will be mentioned under "*refinement.*"

It has not been usual to filter the oil at Tanur, but a small filter press was obtained for the purpose, and a filter vessel for ordinary upward filtering was made but was only used for brine filtering: see below *s.v.* "*filtration.*"

118. The ordinary coastal factories do not properly attend to separation, which is conducted with insufficient speed or thoroughness; there is no washing of the oil which, as elsewhere shown, is simply heated in a pan over an open fire in order to sterilize and drive off any remaining water, the process being imperfect and causing loss by the carbonization of the oil and of impurities which are not subsequently washed out.

Hence it is advisable to have a series of settling pits of small size and of considerable depth in proportion to area and provided with means—

(1) for rapidly separating the oil and water which should preferably be made saline;

(2) for rapidly passing on the partly separated oil from pit to pit, automatically if possible on the principle of the Florentine receiver (see paragraphs 67—69);

(3) for washing and heating the separated oil so as to secure further separation and purification by the coagulation and precipitation of suspended impurities and by vaporizing suspended moisture. See further under "*refinement.*"

119. *Freeing of the oil from all moisture.*—The *fourth point* is that of the proper drying of the oil. If oil is thoroughly freed from moisture there is much less chance of subsequent deterioration, for such deterioration results from hydrolysis, that is, decomposition effected by water; hence, even if subsequent storage is not well carried out so that the oil is exposed to damp air, well dried oil deteriorates under similar conditions much more slowly than oil which contains moisture, since it takes time for moisture to operate if it has been driven from the mass of the oil and can only attack from the surface; moreover the enzymes which accelerate decomposition are only active in the presence of water. Further, in the process of drying by heat the oil is usually raised to such a temperature as to destroy bacteria and enzymes, that is, it sterilizes the oil; consequently well heated and dried oil is almost insusceptible of decomposition if decently treated.

In the United States of America the complete removal of all water is insisted on, but it is not clear whether this is effected by heating except when "refinement" is actually undertaken. In one paper (Greer) it is stated that after the oil has passed "from the last of the series of separating tanks to the cooking tanks it is practically free of water. It is then cooked to the boiling point by steam injected from the perforated pipes placed in the bottom of the tanks." The boiling point apparently means that (or something higher) of boiling water (for oil does not really "boil"), but it is not clear why steam is injected through "perforated" pipes, since while driving off, at above 212° F., the slight residuum of moisture in the oil, it must add a great deal more as it condenses in the act of heating up the oil. Probably *closed* coils are used for this "cooking"; the process then becomes clear: pressure steam, say at 300° F., heats the oil to above 212° F., and thus drives off as steam any remaining water contained in the separated oil, and, while perfectly drying it, also sterilizes it. But, as shown in paragraph 116 *supra*, this open steaming is an excellent means of washing and purifying the oil if this has not already been effected.

The oil at Tanur, being small in quantity and well prepared, washed, separated, and stored in closed vessels—sometimes

hermetically—has not usually been dried; the addition of this process is desirable since steam is available; it is only necessary to fit a closed coil—copper preferably, but a grid of strong iron pipes will do—to one of the tanks. In fact, a drier on this principle was made for the writer in London and is now at Tanur, being a vertical, galvanized steel cylinder, provided with an externally tinned copper steam coil (closed) which traverses it internally from top to bottom; the oil in a small stream from a slightly elevated tank is let in at the bottom and rising slowly in the cylinder is heated to above 212° F. by the steam coil and issues dried and sterilized from an outlet tube at the top whence it can be directed at once into storage vessels. As the steam coil is closed the steam does not come in contact with the oil.

120. As elsewhere shown, the practice, when carried out in the coast factories, is to pour the oil into a vessel and heat it by open fire; this leads to serious loss, since much of the oil must be, and is, scorched, so that oil is wasted by carbonization and seriously damaged in odour and colour; hence a low price. If steam is not available it is always possible to heat the oil above the point of boiling water, 212° F. and thus to drive off any water, by putting the oil into thin metal receptacles, e.g., kerosene tins, and placing these tins in a bath of strong brine, preferably of calcium chloride, which is heated by an ordinary open fire or furnace; the brine attains a heat considerably above 212° F. and consequently also raises the oil in the tins to a similar temperature, so that any water in it is driven off. Brine from calcium chloride is better than brine from common salt since it does not attack iron; moreover it can be raised to a very high temperature if the solution is strong; the material is very cheap. But common salt has the advantage of being always at hand.

All oil should, after careful separation, be deprived of any residual, suspended moisture by heating as above, viz., either by steam or by treatment in a brine bath.

121. *Proper storage.*—The *fifth* point is storage. If well purified dry oil, free from moisture, is properly stored, it will remain perfectly good and sweet indefinitely; if such oil is improperly stored it is apt gradually to go rancid; if oil is not properly purified and freed from moisture it will certainly deteriorate but the amount and rapidity of such deterioration may be minimised by good storage. In illustration of the above it may be mentioned that

ghee and oil have been taken from Egyptian tombs where they were placed from 2,500 to 4,000 years ago; being dry oils (ghee, etc.) and kept sealed in the dry atmosphere of Egypt and in the total darkness of a tomb, they were quite unchanged and free from acidity (only one was slightly acid) and rancidity. On the other hand as shown in paragraph 94 and as is otherwise well known, the badly stored fish oils of the small coastal factories may be found within a year to contain over 50 per cent of fatty acids and to be hopelessly rancid and consequently of low money value. Hence both the proper initial preparation of the oil and its proper storage are of great importance. Proper preparation has been dealt with above, and will be further dealt with *s.v.* "*refinement*"; storage has yet to be considered.

122. The first stage of oil deterioration is the formation of fatty acids by the decomposition of the oil; this itself is a real deterioration except when used for certain technical industries such as soap-making; it is bad for leather work, lubrication, and for all edible purposes. This decomposition is caused mainly by enzymes or chemical ferments which are active in the presence of light, air, and moisture. As shown above, properly prepared oil, washed and separated from its main impurities, dried, and perhaps filtered, will keep good indefinitely if stored in closed receptacles; hence all oil which it is desired to keep free from acidity should, after purification, drying, etc., be stored *not* in open pits or tanks loosely covered with mats, but in iron or masonry tanks, tight wooden or steel barrels, closed kerosene oil tins, etc. If the finished oil has been heated for drying purposes as suggested in paragraph 119, it should be run direct into receptacles, and these should, as soon as possible, be filled to the brim so as to exclude air, and closed.

If the separation of water and drying has not been quite complete, it will be found, after a settling period, that dirty water has accumulated at the bottom of the receptacle; this should be drawn off as soon as possible by means of a tap. Oil thus stored, should, if it has been properly prepared, washed, and dried, be far superior to ordinary oil stored in pits, and should get a better price.

123. *Recapitulation.*—To sum up; oil should be prepared from fresh, untainted fish, and, if delay is likely to occur, the fish should be freely salted; the oil should be rapidly separated from the fish mass in the operations of obtaining the oil; the water, full

of impurities, which flows with the oil into the receiving pits, must be rapidly separated from the oil and the oil well washed with boiling water which must also be rapidly separated; the oil must then be "dried," that is, deprived of any residual water in minute suspension in the oil; and, finally, the washed and dried oil must be stored in proper receptacles, free as far as possible from the influence of air, light, and moisture.

124. *Use of salt.*—This addition to the material is important. It should be a rule to mix salt in sufficient quantities with all fish which cannot be worked off in, at most, 12 hours' continuous work; such addition would entirely prevent taint, and would consequently improve the quality of the oil and minimise offensiveness. In paragraph 5 on page 54 and paragraph 8 on pages 69 and 70 of Bulletin X, it is shown that ungutted sardine fresh from the sea can be preserved for a considerable period by being simply "roused" (thoroughly mixed) with salt, the proportion of salt not exceeding one-seventh of the weight of fish; for very short periods a smaller proportion suffices. Hence all that is necessary when sardines are received in excessive quantity is to rouse with, say, 10 per cent of salt, all sardines in excess of the quantity which can at once be worked off. This causes some extra expense but produces the following advantages:—

(1) prevention of taint and consequently,

(2) superiority of oil both in colour, odour, and value;

(3) obviation of public nuisance;

(4) ability to work at leisure so that work is better and necessary rules can be observed;

(5) greater readiness of the oil and water to separate in the separating pits owing to the increased specific gravity of the water;

(6) diminished tendency of the contents of the effluent water to putrefy, and consequent avoidance of nuisance and ability to handle it;

(7) benefit when irrigating coconut trees which approve of salt; if too saline it can readily be diluted.

REFINEMENT.

125. The refinement of menhaden oil is mentioned in paragraphs 39 and 40 supra; generally speaking fish oil is not refined

to any great extent, and, as mentioned in the preceding paragraph, on the Madras coast the product is almost entirely sold as oil-cum-stearine. But it appears probable that Madras sardine oils (and possibly liver oils) may, if refined, be useful in ways which at present are not at all or very slightly possible or even contemplated ; for instance in first qualities as edible oils in canning, or as medicinal oil, or for hydrogenation into edible fats ; in second qualities for leather, paints, etc., for which the crude oils are unsuitable ; or, again, for hydrogenation as soap fats. Hence a brief description will be given of refining methods, as taken partly from text books (see list of authorities in the Appendix) to which reference must be made for details, partly from local experiments.

But it should be remarked that West Coast sardine oils prepared from fresh or untainted fish, boiled by steam, rapidly and thoroughly separated from the effluent water, *thoroughly* washed at once to remove impurities, the residual water (in suspension) removed as soon as possible, and the oil then stored in *air-tight* receptacles such as sound casks, etc., requires very little purification ; it was fine yellow A. 1. oil, prepared as above without subsequent refinement or any treatment save that mentioned, which was characterized by a firm in Great Britain as "unique" ; similar oil has long been used in the sardine cannery not merely for frying but also, in due proportion with vegetable oils, in packing the tins of fish ; it has also been accepted as medicinal oil, and consumed without demur, being almost inodorous, tasteless, and free from acidity. But even this oil may be further improved by refining processes for the above purposes, while the common oil can be greatly elevated in class and consequently in the scope of its uses and therefore in demand and in price, by refining methods. But refinement is only needed for certain classes of work, and, in any case, should be suited to the oils in hand and to the intended uses of such oils. The methods will be briefly described under the sub-heads of purification, clarification, filtration, dehydration, neutralization, deodorization, bleaching, and removal of stearine. For further details various text books must be studied.

126. *Purification.*—Crude fish oil straight from the separating tanks is usually contaminated by minute fragments of fish, by albuminous fluid matter, and by a certain amount of water containing gluey and other matters. The organic matters rapidly putrify and so give to the oil part of its malodorous character, while

the water, especially in the presence of these impurities and of light and warmth, rapidly hydrolyses (decomposes) the oil and sets free some of its fatty acids which are not only malodorous in themselves, e.g., clupadonic acid, but further decompose and cause rancidity ; hence the bad odour and taste of crude, unpurified fish oils. The first purifying process then, is that of removing impurities. By receiving the crude oil from the separating tanks in deep cisterns the solid impurities slowly fall to the bottom, but to prevent decomposition and to save time—since the lighter suspended and fluid impurities take very long to settle this precipitation must be hastened. In the ordinary practice of the small factories it is usual to pass the crude oil through a straining cloth of gunny into a boiling pan, usually a vertical cylindrical pan set over an open fire ; the larger impurities are retained in the cloth and the oil is then heated ; this heating coagulates the albuminous matter, drives off the suspended moisture, and sterilises the whole mass of oil which is then poured off into casks or into a mere open storage pit without further straining, still less filtering. Since the oil is sterilised and most of the water removed, the oil is to a certain extent guarded against chemical action, especially if drawn off at once into tight casks and thus secured from air and light. But the coagulated and other matters still remain in the oil of which they form an appreciable amount ; moreover if stored in open pits, merely covered by planks or mats, air has considerable access to the oil, and since a good deal of the water and impurities still remain in the oil, hydrolysis begins and after some months of storage, may result in a very large percentage—even above 50 per cent (paragraph 94)—of free acids (acidity) and in serious rancidity, with the malodorous and other results above mentioned ; hence a low price for the oil. Moreover, by the open fire method of heating, the oil is often badly scorched which adds a further unpleasant odour and a dark or even black colour which cannot possibly be removed since it is due to carbonization of part of the oil ; such carbonization also means loss of so much oil as has been carbonized.

The Tanur Yard (see paragraphs 64, 117, etc., supra) consequently washes its oil immediately after separation : the oil is good to start with, being from fresh steam-boiled fish, and much of the oil is skimmed from the boiling mass and is but slightly contaminated with the albuminous matter found abundantly in oil from the presses. If the oil, usually poured into tall separators, is treated

with plenty of boiling water, thoroughly mixed up with it and then allowed to settle, the impurities will be dissolved in or mechanically carried down by the water, this precipitation being hastened if fine salt is sprinkled at intervals on the surface of the oil, the salt acting mechanically in carrying down solid impurities and also, by uniting with the water and thus increasing its specific gravity, it promotes rapidity of separation. As noted also in paragraphs 71, 116, etc., supra, the oil may be very effectively washed and sterilized by admitting live steam into the oil through a perforated coil; grain salt may be added after the steam is turned off. Steam heating tends to volatilise the substances which give fish oils their peculiar odours.

The result of such washing is a turbid layer of water below a layer of washed oil which is then drawn off by taps, syphons, etc., the Florentine receiver system (paragraph 67 supra) might be conveniently adapted for this separation. The oil thus washed and separated may then be boiled by steam, either by a closed coil, or in a jacketed pan, or as suggested in paragraph 72 supra.

It is stated (Lewkowitsch) that in Japan the crude sardine oil is "refined" by heating it to 50° to 60° C. (122° to 140° F.) for an hour and then running it off into wooden vessels where it separates into three layers. The upper layer is liquid and clear, the middle layer consists of solid fat, and the lowest layer of water intermixed with albuminous substances and "scrap." Possibly the heating is by open steam which would account for the layer of water, unless indeed the crude oil is that which comes direct from the separating tanks, containing a good deal of water and minute fragments of fish. The "stearine" is said to be about 30 per cent of the crude oil. This purification is very simple but imperfect.

Oil properly treated should, after settling, be bright and clear since the causes of turbidity, viz., suspended water in very fine particles and suspended organic matters, will have been largely removed. The actual colour however will not be improved, except that it will appear brighter because of the clarity of the oil.

127. *Clarification.*—A further process may be added, viz., that of rapid and complete removal of all foreign substances by clarification; this method is profitable not merely by improving the oil but by greatly increasing the rapidity of purification, thus enabling a manufacturer to use much smaller storage plant and to sell

his goods at an improved price immediately after production and thus be ready to take advantage of a favourable market.

Certain substances when mixed with the oil at once coagulate and precipitate albuminous matters; such are tannin which forms an insoluble precipitate, but this cannot be used where the oil is intended for edible or medicinal purposes; milk when added to oil and heated similarly coagulates, especially if the oil is acid, and precipitates impurities. Other substances such as fullers' earth, kieselguhr (diatomite, etc.) though inert or almost so in themselves, act mechanically on the foreign particles. These impurities, etc., are readily precipitated by settlement in tall receptacles, the clarification being greatly improved as well as hastened by the admixture of the foreign materials (kieselguhr, etc.) which operate mechanically as they fall to the bottom. But in all these cases—and necessarily so in the case of fullers' earth which gives a specific earthy taste to the oil if in contact with it except for a very short period—it is usual to filter the mixture when the coagulated substances or foreign materials are arrested by the filter (and, in the case of materials such as kieselguhr, form the most efficient element in the filter) so that the oil issues perfectly bright, clear, and free from impurities.

128. *Filtration.*—For the purest and best forms of oil, especially when intended for edible or medicinal purposes, filtration is essential. The usual method of filtering in large modern factories is that of the filter press which consists of a number of connected chambers arranged vertically in a common frame in which they are kept in close contact; each chamber is of considerable superficial area compared with its width or capacity. The shallow plates forming—in pairs—the chambers are lined with filter cloths and are connected by a common duct through which the fluid to be filtered is pumped at a pressure which may amount to many pounds to the square inch. The filtrand* is forced through the filter cloth, depositing within the chamber and on the inner surface of the cloth, the impurities, coagulated matter, or foreign materials; the filtrate (filtered oil) is at first slightly turbid but as the deposited layer increases the oil becomes perfectly clear and

* I use the word "filtrand"—though not apparently in present use—to signify the fluid *to be* filtered; it includes the whole fluid with its impurities, admixtures, etc., and obviates the necessity for lengthy phrases such as "the impure fluid to be filtered," etc. "Filtrate"—that which *has been* filtered—is of course in common use.

bright and should be passed at once into its storage receptacles. With these presses the kieselguhr is really the filtering medium, and filtration improves as the layer of material consolidates in the chambers. When it becomes obvious that the deposit has become excessive, the frame is slackened so that the plates can be released; the solid cakes of material are then removed, the filter cloths cleaned, and the press again put together; the cakes may also be treated to recover any contained oil, and the kieselguhr washed for further use.

It is suggested, in view of observations made on the extraordinary anti-enzymic action of asbestos on nitrogenous and other substances (British Medical Journal, November 22nd, 1913) that, for very fine oils, asbestos, which is abundant and cheap in India, may be used in powder as filtering material; a sufficient quantity may be intimately mixed with the impure oil and left in contact for at least one night; the mixture may then be passed through the filter press. According to the observations mentioned in the Journal the exudate (filtrate) should be free from nitrogenous matter as such.

A small filter press is available in the Tanur Yard.

129. The value of filter presses lies in the great effectiveness and rapidity of their action by which fluids which would take many months to clear by ordinary gravity settlement may be more effectively purified in a few minutes or hours, so that a minimum of storage room and receptacles is required, capital is locked up for a minimum of time, and the manufacturer is ready at any moment to take full advantage of the market. But filter presses are expensive and not always necessary though desirable for first-class edible goods; when ordinary filtering may be desirable, their place can be taken by a variety of filters of very simple character and cheap material. A simple and most effective filter is composed of nothing but cloth, moss, cotton waste or pulp, paper pulp, coir, charcoal, and even clean sand, put together in layers in a wooden tub or box through which the filtrand is passed by gravity. The containing vessel may be of iron (preferably galvanized) or wood and may be of square or cylindrical section; it must be well made, strong, and water-tight but with open top. The bottom is usually cone shaped and is provided with an inlet cock and a wash-out cock; above the cone is a perforated plate, resting on lugs or on a rim in the container; on the perforated plate

is placed a filter cloth, then a few inches of filtering material perhaps of different kinds; this arrangement is duplicated, so that the total depth of the filtering bed may be perhaps a foot. On the top of the filtering layers is placed a perforated plate similar to that at the bottom. Above this is placed a screw set centrally in a frame which is affixed to the top of the filter body; by this screw the filtering media can be conveniently packed and compressed to any desired degree. An outflow tube leads away the filtered oil from the top of the filter which is on the *upward* flow principle. In working the filter the oil is led by a pipe from a cistern placed a few feet above the filter, into the bottom of the filter below the perforated plate, through which and the superincumbent filtering media, the filtrand passes upward, issuing clear and bright above the top plate. The upward system is generally adopted in these filters, especially if solid matters, heavy coagulations, etc., are present in the filtrand, for these at once fall to the bottom of the cone (whence they are periodically removed through the wash-out cock) and do not affect the filter proper, whereas in a downward flow filter all the impurities, coagulated matters, etc., collect on the top of the filter and obstruct filtration. A rough sketch is appended; a galvanized iron filter precisely of this pattern was made for the Tanur Yard.

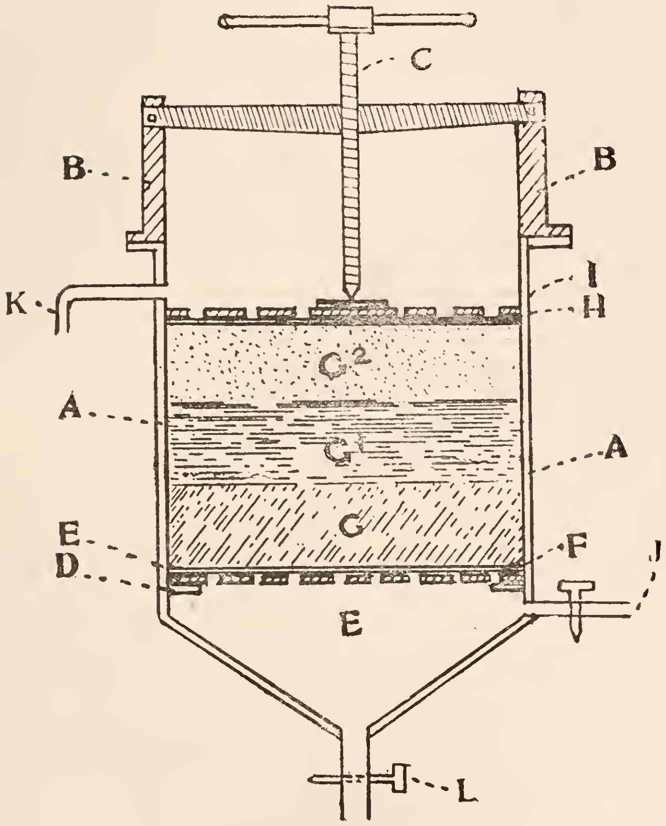
Moss is said to be particularly suitable for oil filtration; this is abundant, especially in the monsoon, on the West Coast; it should be gathered during the rains, washed from earth, etc., and carefully dried. Coir, well washed, is also suggested; it would require considerable compression to act satisfactorily but might have other materials mixed with it. Cotton waste, paper pulp from unsized paper, and other forms of cellulose are much used in filters, but when used with oil the material must be kept from the air, since the rapid oxidation of the oily cellulose frequently causes spontaneous combustion; hence the oily mass must never be left lying about in bulk, but should be pressed and washed at once.

The filtering media require occasional changing, when the used material should be pressed, washed with alkali to recover any residual oil—as a rough soap—and then either prepared for further use or thrown away.

There are many other forms of filter, including the simple bag filters of gunny, flannel, cotton, etc., or suction filters in which the filtrand is sucked by a pump through a filter drum or chamber

OIL FILTER.

(Vertical Section.)



A, filter body (iron or wood).

B, wooden frame bolted to A.

C, screw passing through B to compress filtering media.

D, lugs or rims supporting perforated plate E.

E, perforated plate resting on D.

F, filter cloth resting on E.

G, G1, G2, filtering media, e.g., coir (with asbestos, etc.), moss, cotton waste, etc.

H, filter cloth above G and below I.

I, upper perforated plate.

J, oil inlet below E.

K, filtered oil outlet above I.

L, wash out cock.

N.B.—This filter may also be used for filtering dirty brine, etc.

filled with any convenient filtering medium; one of these was obtained for the Tanur Yard. For details the text-books and trade catalogues must be consulted.

130. *Dehydration.*—Oil pressed from fish which themselves contain some 75 per cent of water, is boiled and washed with water, and consequently retains an appreciable amount of water however carefully separated in the ordinary way, viz., by settlement. This process is lengthy because the water is suspended in very minute particles throughout the oil, and consequently, though heavier than the oil, finds difficulty is sinking through the viscid fluid.

Hence oil apparently well separated, will yield a considerable deposit of rather dirty water if kept undisturbed for a few weeks in a tall receptacle; the process is also somewhat imperfect and, in any case, demands a long period, which involves the obvious disadvantages of locking up capital for a long time and of requiring large storage, together with the still greater disadvantage that the water (and impurities contained in it) prejudicially acts upon the oil in which it is suspended; hence acidity and rancidity, while purchasers always discount the water contents by a deduction from price. Moreover, water, even when pure and in very small quantity, prevents oil from complete clearness, since the minute particles reflect the light and cause apparent, but not real, turbidity. Hence for the best oils, especially for edible and medicinal purposes, the oil must be thoroughly dehydrated before storage.

In paragraphs 119 and 120 supra, modes of drying are detailed, and for the best class of oils, steam drying is strongly advised, the dried oil being passed at once by a pipe from the steam drier direct to the storage receptacle which should be filled full and closed. Complete dehydration is sometimes obtained by the use of calcium chloride, plaster of Paris, or even common salt; these may be mixed in the form of rough powder with the oil which is then filter pressed, or the oil may be passed (filtered) through a layer of the material. These latter refinements are only needed where absolutely dry oil is required.

Heating must be cautiously effected, especially where the oil is of high class or for edible purposes; if effected by the primitive process of open fire heating it is certain to darken considerably and may be badly scorched; even with steam or in a bath of calcium chloride solution, the heat should be no higher or of longer duration than is necessary since there may otherwise be an

appreciable darkening where the oil is of a fine yellow colour; such darkening will lower price when the oil is required for edible purposes for which a light or bright yellow is always desirable. One text book recommends the "gentle" heating of the oil "by steam pipes to a temperature not higher than 50°C. (122°F.) while a current of air is blown through", probably the air is warm, and the friction of the air currents increases the heat. In the Tanur Yard there is a machine for this purpose consisting of a strong galvanized steel vessel closed air-tight above and provided with (*a*) a closed tinned copper steam coil inside for heating the contents, (*b*) a Korting steam air-ejector at the top of the vessel, (*c*) a perforated copper coil inside the vessel at the bottom and communicating with the outer air. The vessel is two-thirds filled with oil and closed air-tight; steam is then turned on through (*a*) till the oil is sufficiently heated as above; (*b*) is then set to work, and by causing a partial vacuum within the vessel (upper part) air is sucked through (*c*) and passes in numerous rapid currents through the warm oil which it further heats by friction. The air should be dry and warm for the best effects. The oil is said to be greatly brightened by this process, obviously by dehydration. The machine however has never been used since refinement has not been practised there.

131. *Neutralization.*—So far the "refining" processes which have been considered are those advisable with all classes of oil to fit them for the particular market for which their qualities suit them, and also to prevent deterioration while awaiting such market or subsequent use; filtration indeed is not so necessary, but is merely adopted to ensure rapidity and completeness as against the gravity settling method. But where high-class oils are desired, as for edible and medicinal oils, or in leather preparation, or for "browning" etc., work in arsenals, or for hydrogenation, it is necessary further to improve oils as in the process mentioned below; acid oils are not permissible for edible goods or for hydrogenation; good colour is necessary in edible oils, and the only permissible odour is the slight fishy odour similar to that observed in good cod liver oil; moreover, acidity is a precedent of rancidity. Hence *neutralization*, that is the removal of fatty acids and the general improvement of good class oil, mainly for edible and medicinal purposes, is advisable. For ordinary technical purposes (jute batching, steel tempering, soap-making), the presence

of free acids is immaterial or even—in soap-making—welcome; for other purposes oil should be neutral. Now for edible oils chemical treatment with acids, bichromates, etc., *is not permissible*, but mere treatment with alkali is not only harmless but highly beneficial. All unrefined oils contain a percentage of fatty acids, from a mere trace in fresh, well prepared oils, to a proportion of even 50 per cent or more; this is specially noticeable in ordinary coast oil after the storage, in mere masonry pits, of oil not properly purified when manufactured.

This neutralization is readily effected by mixing with the oil a solution of caustic soda, or, even better, of the carbonate since fatty acids readily combine with the carbonates, which, moreover, are cheaper than caustic and are free from caustic properties. The acidity of the oil is easily ascertained quantitatively by testing it with potassium hydroxide. The ordinary tests for acidity, viz., those of taste or of litmus paper, are insufficient; these tests will prove acidity but not the quantity of acidity, and since there would be considerable loss by saponification or by wastage of alkali if an undue amount of alkali is used, a fairly correct quantitative test is essential.

132. The improvement of low-class fish oils was referred by the late Board of Munitions (India) to the Rev. Father Caius of Trichinopoly who submitted various reports, the gist of which is that caustic or carbonate of soda improves bad oils. The experiments have since been repeated, with additions, at Coonoor with, of course, similar results on acidity, rancidity, and odour, since bad odour depends largely on certain of the acids. The method adopted at Coonoor was as follows: first, steaming with pressure (20 lb.) steam and, secondly, treatment of the steamed oil with either sodium hydroxide (caustic soda) or preferably, sodium carbonate. The mere steaming resulted in a reduction of acidity by from 25 to 50 per cent, the larger relative reduction being in the better classes of oil with only 5 per cent of acidity. The remaining acidity was then neutralized by alkali. It was found that 15 minutes steaming were ample, no appreciable decrease in acidity taking place in longer periods; steam drives off only volatile acids.

But it is doubtful whether such manipulation will pay commercially in this country as regards low-class oils; firstly, even sodium carbonate costs a good deal since it has to be imported and carried long distances; secondly, the process in unskilled hands at the petty factories is apt to be wasteful of oil and alkali; thirdly, the

loss of oil by saponification is large in accordance with the acidity of the oil and there is, ordinarily, no local market for the resulting soap stock so that the saponified oil is a dead loss ; fourthly, labour and fuel are appreciable items of cost. Possibly a central refinery drawing to itself large quantities of crude oil and improving it by the above and subsequently mentioned methods, might succeed commercially, since, if at Calicut, it could sell its soap stock to the Government Soap Works for use in fish-oil soaps (saddle, insecticidal, etc.), or, if located elsewhere, could itself make such soaps.

133. In the above Coonoor experiments, oils were obtained both from the Government Yard at Tanur (A oils) and from various private factories (B oils) along the Coast. The Tanur oils needed little neutralization, the acidity ranging between 1·9 and 5·2 with one sample at 13·4 per cent ; B oils gave seriously bad results showing acidity from 33 to 46·3 per cent with a loss of oil up to 51 per cent, the soap stock (oil, alkali, and water) mounting up to 44 per cent. The following table displays results :—

Oils.	Colour.	Odour.	Acid value.	Acid value after steaming.	Properties after neutralization.			Yields.		
					Colour.	Odour.	Acid value.	Crude oil.	Refined oil.	Soap stock.
A 1	Yellow.	Fishy.	1·9	No Experiments were made.						
A 2	Do.	Do.	2·9		Do.	Do.				
A 3	Golden yellow.	Do.	3·9	1·9	Light straw colour.	No odour.	Nil.	No quantitative experiments made.		
A 4	Orange yellow.	Markedly fishy.	5·2	3·2	Pale yellow.	Slightly fishy.	Nil.	100	94	5
A 5	Orange red.	Fishy.	13·4	7·1	Reddish yellow† (amber).	Do.	Nil.	100	84	12·5
B 1	Brownish red.	Putrid scorched and fishy.	35·3	24·9	Orange red.	Do.	·4	100	60	37·5
B * 2	Orange red.	Do.	33·0	28·2	Deep red and brilliant.	Do.	Nil.	100	56·3	41·3
B * 3	Deep red.	Do.	38·5	30·1	Orange.	Do	Nil.	100	56·3	42·5
B 4	Brownish black.	Putrid and fishy.	46·3	32·9	Deep red.	Do.	·6	100	48·9	38·3

* After neutralization preceded by steaming, there were found with soap stock at the bottom of the flask, scales of fish and other organic matter which were originally suspended or dissolved in the oil.

Steaming for about 15 minutes with 20 lb. steam suffices for the removal of practically all the *volatile* acid matter.

† The darkening in colour is due probably to prolonged heating during drying as the undried oil, after neutralization, is of a lighter colour.

The first two A oils were so good that experiments in refinement were unnecessary ; they were of the quality described as " unique " in the market. The third A oil was entirely deprived of its free acid by steam and alkali and in the process became very pale ; Nos. 4 and 5 showed similar results.

The B oils, which were privately made oils of inferior quality with many impurities, show that some improvement is possible but only at great loss of oil and considerable expenditure ; the results were quite incommensurate with the loss and show that really low-class oil cannot be improved with commercial success.

This table is the justification for the remarks in paragraph 132 ; it is evident that the improvement by neutralization of badly prepared low-class oils can hardly be a commercial proposition, unless other considerations warrant it ; such oils had better be sold for technical purposes in which acidity, odour, colour, etc., do not matter ; they will fetch only a low price but they cost comparatively little to produce. It is to the improvement of the methods of original preparation that attention must be paid: the Tanur oils from the Government yard show that careful attention to processes means oil that requires little subsequent manipulation and consequently little cost or loss, while they will fetch a superior price ; moreover, since West Coast oils are usually required at great distances (e.g., Cawnpore, Calcutta, Dum Dum, etc.) if they are to compete with whale and other imported oils, and since the freight is the same on a ton of good or a ton of bad oil, it pays best to produce and transport good oils.

134. *Deodorization.*—As already explained, most of the bad odour from which fish oils suffer is due to bad original preparation ; the use of tainted or stale fish, want of immediate and thorough separation of organic impurities and water which cause hydrolysis and the liberation of malodorous acids, scorching by fire, and so on. The best oils, properly prepared, have only a fishy odour, not strong, and comparable with that of good cod liver oil ; this cannot be entirely got rid of, but may be minimised by treatment and by subsequent precautions in storage (paragraph 121) to prevent subsequent acidity ; such deodorization, if combined with other refinements, fits our fish oils for edible and medicinal purposes for which they have already been used.

In studying neutralization by sodium carbonate preceded by steaming, it was found that practical deodorization was also effected ; any putrid or accessory smell was always removed,

leaving only the fishy smell belonging to all such oils, but varying from very faint in the best classes to ordinary in the others. The reason is obvious; steaming—by pressure steam—volatilized certain of the malodorous acids as shown by the loss in weight mentioned in paragraph 132, and the alkali neutralized the remainder; scorched, that is, partly carbonized oils retained however their characteristic scorched smell and, of course, colour. Steaming by itself produced great improvement, and in the case of low-class oils this could be adopted without material cost where a boiler is available; it suffices to pass pressure steam through the oil by means of a perforated coil for a certain period; the process not merely deodorizes, but washes and sterilizes the whole mass. As pointed out in paragraphs 32, 35, 116, steaming is a regular part of the American manufacturing process.

Hence, where possible, steaming should be resorted to, with the subsequent use of sodium carbonate in the case of oils which it would pay so to treat. High class oils thus treated are perfectly suitable for edible and medicinal purposes where such oils are needed.

135. *Decolorization* (*Bleaching*).—Ordinary Coast fish oil is brown to blackish in colour; the blackish shade is usually due to scorching in the process of cooking and of rude sterilization (in the small private factories) by heating the oil after separation from the mass of water; see paragraphs 57 and 58; this colour, being due to carbonization, cannot be removed. The brown colours are due mostly to delays and imperfections in manufacture as detailed above *passim*; some part may be due to slight scorching and is therefore irremediable; good class oils can be bleached. The American practice is noted in paragraph 40. In the Coonoor experiments (see table in paragraph 133) steaming, followed by neutralization with sodium carbonate, had a very marked effect, bleaching light orange or amber (Tanur) oils in one case to a very pale, almost water-white, oil, and in another case to a pale yellow or light straw colour; in the case of brown oils there was slighter effect and even this was probably due in general to clarification; in several cases the oil was slightly darker but much brighter, and the darkening was entirely due to long continued heating in attempts to drive off all residual water.

The general result of the Coonoor experiments is that decoloration by the simple means adopted is but slightly possible with dark common oils, but can be effected to a large extent and very

readily by steaming and neutralization in the case of good oils when, however, it is not *always* desirable, since a bright yellow oil generally meets public demands better than a pallid or very pale oil.

136. In Tanur it was attempted to bleach orange coloured oil by exposure to the sun but no perceptible effect was produced after exposure even for weeks, probably because air was excluded during the process. But from the decided statements in the text books it would seem that where bleaching is desirable, this simple and cheap method should be again tried and more thoroughly, since tropical sunlight should be specially powerful. The method as described in one text book is to place the oil in glazed boxes or frames (e.g., of window glass set in frames) of perhaps 4 inches in depth; both sides of the boxes are glazed so that the sunlight passes clear through the oil. A necessary condition is a supply of air; hence the upper part of the box which is closed to prevent impurities falling in, is perforated below the cover to allow of free perflation of air over the surface of the oil. It is said that in 14 days the oil will become white and clear. To hasten or ensure sun-bleaching the addition of certain chemicals is said to be efficacious, but this is not permissible for edible or medicinal oils.

The process is suggested for "oils" in general, but fish oils are not expressly mentioned.

137. In the rare cases, e.g., paints, where fish oil may require bleaching for technical (non-edible) purposes, chemical bleaching is possible, for which the text books must be consulted; probably sodium sulphite is the cheapest, easiest, and most innocuous chemical, but no experiments have been made with it or other chemicals. It is expressly stated that chlorine darkens fish oils.

Decoloration is mostly needed for edible and medicinal uses and, to some extent, for hydrogenation. Fish oil is not generally used as oil in ordinary soap making as it is difficult to disguise its very persistent odour, so that it is almost entirely used for saddle soap and insecticidal soaps in which colour does not matter. For hydrogenation the oil should be a good yellow *neutral* oil, and this loses its specific odour when hydrogenated, forming a white, almost inodorous, fat; it then becomes useful, in the place of tallow, for ordinary soap making. In leather working and for paints and use in arsenals the colour should be yellow to light brown, but for ordinary technical purposes such as jute batching,

and greasing pottery moulds, and of course, steel tempering, the brown colour is generally immaterial and decoloration therefore unnecessary, except as an incidental adjunct of purification where such is necessary in order to render the oils neutral and free from unpleasant and improper odour.

138. On consideration of the previous paragraphs 125 to 137, it will be seen that refinement except of a simple character, viz., steaming and treating with alkalis of which sodium carbonate is simple, cheap, and efficacious, is seldom necessary or profitable except in the case of the better class oils which are to be fitted for edible or medicinal purposes. What is mostly desirable in these cheap fish oils is proper initial preparation; if this be observed little subsequent or complicated refinement is needed or desirable; if fish oil is prepared from sound materials, separated rapidly from water and impurities, and properly stored, refinement will hardly be necessary save for special purposes; the unrefined oil will sell well for general purposes, while, if refinement is desired, steaming and treatment with sodium carbonate should suffice, though sunlight bleaching may be useful if hereafter found successful.

It will also be noticed that the above simple method of refinement produces many useful effects *simultaneously*; steaming drives off volatile malodorous acids, washes the oil, coagulates (especially with alkali) any suspended impurities such as the proteins and albuminous matters and causes their precipitation; the alkalis and steam destroy ferments and neutralize acidity; the oil is thus simultaneously purified, deodorized, bleached, cleared, and brightened, especially when any subsequent drying removes all residual moisture.

139. All fish oils contain a quantity of "stearine" (so called) or "fish tallow" which is a whitish fat deposited by the oil, and amounts to about 25 to 33 per cent of the whole quantity—see paragraph 39 regarding menhaden stearine and paragraphs 103 and 104 on the general subject. As shown in those paragraphs the only way to remove stearine entirely is by winter cooling or by artificial refrigeration coupled with powerful pressing; none of these is available on the West Coast, so that it is only possible to remove stearine by decantation of the clear oil after settling; the remaining stearine, which contains a good deal of oil, can be strained or filtered and will then give up, but only imperfectly, some of the entangled oil. Fortunately, for all technical purposes the stearine

is as useful as the oil; more so in the matters of lubrication and greases, for hydrogenation, etc. Hence, except for edible and medicinal purposes, the fish oils are usually sold cum-stearine.

FISH MANURE.

140. This name is applied to the fertilizer produced by simply drying the whole fish (sardine) on the sandy beach instead of boiling it for oil and guano; it is an old method of utilizing—even for food—the masses of sardine which are frequently brought to shore and which for lack of time and means cannot be properly cured. The fish is simply spread in layers in the sun on the loose sand, turned over occasionally, and, after some days, when dry, is stored and sold. No salt whatever is used, so that the ungutted fish is tainted long before it is dry; if the weather is cloudy or rainy it may remain on the beach literally for weeks, and, while thus forming a grave nuisance, loses much of its value by the natural evolution of ammonia and by the attacks of insects, birds, and dogs innumerable; on unfavourable occasions little but scale and bone is left. Another source of damage is the unavoidable admixture of sand, especially when fish are fat; the oil is liquified by the heat and then dries on the exterior, so that quantities of sand adhere to the fish and a great deal is added when scraping them together. The purchasing firms allow for 15 per cent of sand in their contracts, deducting further for any excess, but, usually from fraud, the admixture often far exceeds that percentage; in 15 invoices of 1911—13 taken at random, the amount varied between 15 and 33 per cent and in one case, seen in London, the sand was 44 per cent of the parcel. This matter is dealt with more in detail in the annual reports of the Fisheries Department; see Bulletin No. X, pages 35 and 36, etc., and below *s.v.* "adulteration."

141. Considering all these sources of loss it is not surprising that the manurial contents, nitrogen and phosphoric acid, are somewhat low, usually about half the normal contents of the whole fresh fish.

As noted above (paragraph 82), while a large firm guaranteed 8 to 9 per cent nitrogen and 7 to 8 per cent phosphoric acid in boiled and pressed fish guano which they priced at Rs. 100 per ton, they only guaranteed 5 to 6 per cent and 4 to 5 per cent, respectively, for "milled" fish (ground and to a large extent freed

from sand) priced at Rs. 55 ; while for ordinary beach dried stuff they would give no guarantee and priced it at Rs. 40. No analyses except those quoted in paragraph 82, are available; moreover the stuff varies so greatly that analysis would be useless as a guide; some stuff is little but skin and bone.

142. A simple improvement devised at Tanur is recorded on pages 69 and 70 of Fisheries Bulletin No. X as follows :—

"The absence of the oil in the fish and the poor prices given for beach-dried fish led me on returning to Tanur to consider methods of drying *lean* fish without boiling them. Two methods were adopted, viz. (*a*) that of light and brief salting followed by sun-drying, and (*b*) that of artificial drying. In both cases the object is to avoid the loss caused by several days' drying, *without salt*, on the beach, where putrefaction, loss by soakage, birds, insects, etc., cause great loss of nitrogen and of actual material, besides being a nuisance to the public; further and great loss is often caused by rain on the drying material. When the fish are even lightly salted and then dried, not only is putrefaction entirely prevented but the tissues are hardened so that there is less breakage of the fish and loss of debris, nor are the fish attacked by insects. Hence salted fish yield larger quantities of better manure than unsalted fish, and they are not injured by rain since they can be stored without putrefaction till the rain ceases. It is found that one hour in salt is a sufficient protection; the salt actually used up (by absorption and wastage) is about one-twentieth of the weight of the fresh fish or one and one-third maunds per ton, and consequently costs at fish-curing yard prices (As. 10 per maund) about Rs. 4-8-0 per five tons of fresh fish or Rs. 3 per ton of dry fish, since five tons fresh fish thus treated become about 1½ tons dry fish. This fish has been analysed and showed 6·78 per cent of nitrogen, so that it is worth retail at least Rs. 65 as against Rs. 40 per ton of *ordinary* beach-dried fish. Hence there is not only large pecuniary gain but an economic gain to society in the saving of the nitrogen, etc., which would otherwise have been lost by putrefaction and other causes.

The cost of artificial drying is much the same, and it is found that the fish when dried by strong heat, say 300° F., break up and become like guano; this part of the experiment will be continued this year in a proper drier now being built for this purpose and for drying the press cakes rapidly and without loss."

It will be noticed that 5 tons of this lightly salted fish dried into 1½ tons fertilizer as against 1¼ tons of unsalted fish ; this is doubtless due to the hardening of the tissues by the salt so that breakage is minimised and also the loss of weight by putrefaction.

The percentage of nitrogen in this larger quantity of lightly salted material is noteworthy ; other analyses of similar material gave 6·34, 6·63 and 7·43 of nitrogen and from 5 to 6·56 of phosphoric acid. This confirms the excellence of this very simply prepared manure ; the method however is mainly intended for *lean* fish, since all the oil in the fish goes into the fertilizer which is bad for the buyer and for the soil ; if the fish is at all fat, it pays better to boil and press it as usual. Similar whole lean fish, entirely unsalted but dried artificially in a drier, gave the large percentages of 7·59 nitrogen and 6·88 phosphoric acid showing the high manurial value obtainable by simple drying in artificially heated driers.

143. The drying experiment was not continued as the building and working of an economical drier was beyond the technical resources of the yard. Probably a masonry drier, either vertical or horizontal, worked not by trolly carriages as in the abortive Tanur drier but by a conveyor, would be suitable ; a vertical drier (wrongly called " horizontal ") is roughly described on page 439 of the Imperial Institute Bulletin, Volume XII, No. 3 for July—September 1914.

144. The price of beach-dried fish varies immensely from year to year, owing especially to the presence or absence of sardine shoals and to the fatness or otherwise of the fish ; but the general level of prices has, since 1906, gone up very heavily. At that time Rs. 20 to 22 was commonly obtained by the fisherfolk ; in 1911—13 intermediaries sold the stuff to the great Coastal firms at Rs. 28 to Rs. 33, or at Rs. 45 c.i.f. Colombo, 15 per cent sand being allowed at these prices. Owing partly to a rise in general prices of all commodities and partly to increased demand especially for export, partly also to a shortage of fish for fertilizer, the price went up in 1920–21 to Rs. 170 per ton c.i.f. Ceylon, a price which is beyond its calculated manurial value and exceeded that for fish guano.

145. In South Kanara along the sandy sea coast, sardine manure is largely used for tobacco. But in this case the sardine is used in a wet and putrid condition. Pits are dug in the sand to such

small depth as places the bottom well above subsoil water level and the fish in layers alternating with sand, are dumped into the pit which is then covered over and left for two weeks or so to rot. The pits are in no way lined either with clay or vegetable matter and when opened, the whole mass of fish and sand including the sides and bottom of the pits, is removed for use; the sickening offensiveness of the result is beyond description as well known to railway travellers at the manuring period, which lasts for some weeks since the manure is applied, *more Japonico*, to the growing plants on four occasions during a period of more than two months.

There must be great loss of valuable material by soakage notwithstanding the removal to the plants of the surrounding sand, and it would seem better to line the pits with rammed earth or clay, and (or) with vegetable matter. On page 443 of the Imperial Institute Bulletin No. 3, Volume XII, for July-September 1914, lining with clay is advised, while the layers of fish are separated by layers of wood ashes with a little lime and the whole covered up and weighted; the mass is then left for some months to disintegrate and combine.

The ryots have recently found that dried sardines in coarse powder, and also fish guano, are at least as efficacious as their time-honoured fertilizer.

ADULTERATION.

146. *Oil.*—This is hardly possible since fish oil is the cheapest of all oils. The only foreign matters are the dirty water and impurities too often and too largely remaining in the oil owing to bad preparation.

147. *Fish-guano.*—The main item of adulteration is sand, and this addition has become regrettably common. When properly prepared by respectable persons even in the ordinary simple factory, and dried on barbecues with firm surfaces, very little foreign matter can get into the guano; merely a slight amount, below 2 per cent, owing to the strong winds and handling in sandy areas. But the desire for immediate profit has misled too many of the poorer manufacturers and the middleman; the isolated manufacturer, compelled by his want of capital and by the screw of the middleman to accept the lowest possible price, even below cost price, may seek to recoup himself by this addition, plaintively remarking that if he does not add it the middleman will, as is too

often the case in view to increasing profit. The result is that a promising business is being ruined, and it is reported that consignments to Japan have been refused entry there because of the excess of sand. Moreover, this is being practised in cases where distant planters seek to deal direct with manufacturers, for in such cases the manufacturers seek an immediate large profit knowing the difficulty that a purchaser would have in recovering any loss, and caring only for the present.

148. To combat this tendency and various disabilities, the Fisheries Department have sought to obtain a union of the manufacturers in any given locality in a co-operative society for obtaining the following advantages:

(1) Members would support one another against any unscrupulous middleman or buyer who might wish to take advantage of the ignorance and isolation of an individual;

(2) they could, from the society's funds, make loans or advances either in the usual co-operative way or on products handed over to them;

(3) they would obtain information as to markets, whether as to localities or as to current prices;

(4) they would obtain the latest information as to methods of manufacture, whether of oil or of guano;

(5) they would co-operate to obtain any special items of plant as for refining oil, etc.;

(6) they would bulk their products and thus enter the market not as petty sellers of petty parcels, but as owners of important quantities such as 50 or 100 tons of guano or 50 tons of oil, etc., and thus be able to deal direct with large consumers or buyers on favourable terms;

(7) they would, in the interests of the society, watch the work and products of their members, and would thus be able, by refusing badly prepared goods, to fix a standard and compel adherence to it. This is the object of the Japanese Trade Associations for Staple Products, as shown in the following paragraphs 193 and 194 of the present writer's Bulletin on "Agriculture in Japan," published by the Fisheries Department.

"*Trade associations for staple products.*—These associations (Dogyo-kumiai) differ from both the preceding categories, being groups of persons engaged in a particular industry or trade, associated in view to prevent

abuses such as the production of inferior goods, the adoption of harmful methods, and so forth; *cf.* the Fishery Chambers described in paragraphs 116–122 of the note on Fisheries. These associations are not of modern date—especially in the silk industry—except in their present form which is regulated by the revised law of March 1900. This law limits the objects of association as mentioned above, requires that two-thirds of the persons engaged in a given industry within the limits of a proposed association, shall give their consent before its formation, and that when an association has been formed every person exercising that industry within its territorial limits shall join the association, unless specially exempted by the Minister. The associations may also confederate to form a union. The officers of the association or union may examine the products or goods of any member according to rules laid down for the purpose, in order to ensure the quality of the goods, and may mark or brand them in token of quality; goods which transgress the rules or standards of the association may be confiscated and the member may be fined. Annual reports must be drawn up, and while the associations are entitled to make suggestions to the authorities they must also be prepared to give any necessary information. The Government may break up any association for misconduct or acts either illegal or harmful to public interest. The rules of an association must, of course, provide for the standards, etc., by which commodities will be judged

These important Trades Associations numbered 375 at the end of 1904 embracing 67 industries; of these 102 are said to be silk associations, 43 relate to grain producers, 10 to the manufacture of straw plaits, 16 to grass mats, 15 to wood and timber, 5 to fertilizers, 3 to indigo, etc. Hence agriculture is well represented."

See also paragraphs 186 to 192 of the same note regarding Industrial Guilds. The figures have since been greatly increased as shown in the Year Books.

149. It seems obvious that in the interests of the business of the consumer, and of agriculture in general, there should be Government Inspectors who should instruct the immense number of more or less ignorant manufacturers in the best methods, stimulate them into co-operation, assist the co-operative societies both in their ordinary arrangements and in the production and sale of their goods, and at the same time help to enforce agreed-upon standards of production. The Fisheries Department has continuously placed this object before them, but success has not been hitherto very

marked in matters of production and joint sale, partly for want of a sufficient staff with considerable influence; moreover, the classes who usually manufacture these goods are very difficult to deal with, to convince, or to turn from accustomed method. In paragraph 202 of the above mentioned note on Agriculture in Japan details are given of the precautions taken by Government in the interests of agriculture and the agriculturist, to enforce the purity of all classes of "artificial" or manufactured fertilizers, *i.e.*, those made in factories or imported, as distinguished from the ordinary farm yard manures of human excreta, composts, and some cattle manure; guilds for watching over the manufacture and sale and standardization of products are compulsory, so that while in 1904 (on the law of 1900) there were only 5 such guilds for artificial fertilizers, in 1916 there were 30; inspectors are appointed and heavy penalties enforced for wilful adulterations, and all parcels of artificial manure must be labelled with the address of the produce and the percentage of the manurial elements it contains, while regular books of sale must be kept by each seller. But the present bulletin cannot discuss the propriety of such legislation; it confines itself to facts and to the more obvious inferences.

150. But if fish guano and fish manure are to be accepted by the Indian ryot who *cannot* pay high prices for inferior, adulterated stuff, then steps will have to be taken to ensure that these valuable manures shall be what they purport to be and not a quarter or one-third sand. It is not a question of merely deducting part of the price according to the proportion of sand and consequent loss of manurial value, for, if a ton of manure contains 30 per cent of sand and is sent 200 miles by rail and 20 by cart, the consumer has to pay the heavy transport charges *on the valueless sand*; this he will not do, and the trade fails. Hence it is essential if the Indian ryot is to benefit fully by this external source of fertilizer, that he should be protected from the reckless and stupid adulteration now taking place.

PROHIBITION OF EXPORT.

151. This matter is closely connected with that of adulteration, for, as shown in paragraph 150, the ryot will not buy adulterated stuff, and it is useless to prohibit export if the local market is feeble. The point is debatable.

The Board of Agriculture in their conference at Pusa in December 1919 adopted the following resolution, viz :—

"8. That as far as bones and fish manure are concerned, total prohibition of export is necessary."

Fish manure here includes fish guano also. The resolution was not adopted without opposition ; Dr. Mann suggested mere discouragement of export, *e.g.*, by the imposition of an export tax, but the majority accepted the resolution on the ground that the fertility of Indian soils is the primary consideration, and that so long as prices are rendered unduly high by the competition of rubber and tea growers (in Ceylon, the Straits, etc.) the ryot could not afford these manures ; hence their loss to the country which needs them for maintaining its food supply.

152. The following extracts give the views of the Madras Agricultural Experts Messrs. Anstead, Norris, and Sampson, on the one side, and of Dr. Slater, as a general Economist, and of Mr. V. Govindan as Fisheries officer, on the other.

After pointing out the causes of soil exhaustion and the absolute necessity for its recuperation as by the use of human excreta and the stoppage of exports of fertilizers, the former pointed out the ryots' difficulties due to ignorance of fertilizer values, to the high prices of such fertilizers owing largely to the competition of high priced products, to the lack of local supplies and of supplying organization, etc., and they wrote as follows :—

"Illegitimate exports are commodities the export of which lowers the productive capacity of the country, such as, e.g., fish (except for food), whole oil-seeds including *copra*, poonacs or oil-cakes, bones, horns, and food-grains in general.

Fish.—At the present moment, fish is the cheapest form of nitrogen and phosphoric acid to be obtained in South India, and yet the cultivator, except for special crops like tobacco, is unable to use it on account of the high price caused by exports. The ex-factory price paid by exporters for fish guano since the time of the armistice has risen from Rs. 45 per ton to Rs. 100, the price quoted in Colombo in February 1919 being Rs. 160 per ton.

The consequence is that the bulk of this material leaves the country instead of being utilized as a fertilizer to raise the yield of food crops.

If the price were in the neighbourhood of Rs. 85 per ton in bags on the West Coast, it could now be used by the average cultivators, but even this price can only be paid because the prices of food-grains are at present abnormally high.

Until the propaganda of the Agricultural Department has succeeded in teaching the cultivator the value of this form of manure, the price should be kept as low as possible, since he naturally looks askance at paying a high price for a fertilizer about which he knows little or nothing.

For example, at the new Cambodia Cotton Station at Anamalai a start was made without any stock of manure or fodder, and, as a preliminary step, 18 acres of fodder *cholam* manured with 5 cwt. of fish guano per acre are being grown. This crop has already attracted so much attention from passers-by, that the Farm Manager has had requests from neighbouring farmers to purchase for them over 12 tons of this manure. The price delivered is approximately Rs. 5 per cwt. and it would have been impossible to advertise a manure at this price without such a demonstration crop.

The total quantities of fish manures available each year are strictly limited and quite insufficient to meet the manurial demands of the country; hence this material comes within our definition of an illegitimate export, as there is never any surplus which could not be used for developing the resources of the country.

The first effect of prohibiting the export of fish manures will be to bring down their price. Inquiries into the trade show that this will reduce the profit of the middleman, and will not seriously affect the actual producers. It is to be expected that, as the internal demand increases as a result of a wider knowledge of the value of this manure, the price will be steadied, and the present gambling in fish manures will be stopped.

That there is a demand for fish manures and that this demand will increase as knowledge of their value increases, is shown by the fact that in the Kasaragod taluk of the South Kanara district the value of fish as a manure for tobacco is already thoroughly understood, and so great is the demand during the period when this crop is manured, that no guano at all is manufactured on this part of the coast. The whole catch of fish is sold to petty cultivators direct from the fishing boats."

153. On the other hand Dr. Slater wrote as follows :—

"With regard to the proposal to prohibit the export of fish manure, I think this question should be looked at from the point of view of the fishing industry as well as of agriculture. It appears to me that the fishing industry is capable of enormous extension, and that with regard to all

edible portions of edible fish it is most desirable that these be converted into manure by the process of passing through the human body and not otherwise. I think that the friends of Indian Agriculture, while rightly aiming at securing large supplies of fish manure for the ryot, should endeavour to reach this result by way of increased catches of fish. I, therefore, would propose, in preference to prohibition of export, that a reasonably heavy duty should be levied on exported fish manure, and on all fish which are not exported in such a way as to be fit for food on their arrival at the intended destination; and that the proceeds of this export tax should be earmarked for the development of fisheries."

154. It is a grave question however whether Indian fisheries, especially in the most southern parts or along the East Coast, are really capable of "enormous extension"; of considerable extension doubtless, but that only by slow degrees as intelligent capital goes into the business and develops catching and curing methods and material. Moreover, though it is most desirable, as the present writer has ceased not to argue and urge, that all edibles—not fish only —"should be converted into manure by passing through the human body," and used, *more Japonico*, as manure (see Fisheries Bulletin on Agriculture in Japan), yet the unhappy fact remains that the Indian agriculturist in general will *not* use human excreta as manure, so that edible fish while serving as food will not subsequently serve the secondary purpose of a fertilizer. Further, it is not at this moment a question of catching more fish (sardine) for edible purposes but of utilizing existing catches; as conditions are, the fish used as fertilizer are the excess beyond that which can be cured and used as food; they cannot be used fresh beyond a certain quantity because they go bad before they can be transported to any distance, and their utter irregularity, both in locality and time, prevent organized refrigerating methods; hence they have to be cured as salt fish, and this is, in general, carried out to the utmost present capacity of the fisher-folk. Hence an extension of catches is not so important as an extension—and variety—of curing possibilities. See on this point, paragraph 89 supra and preceding paragraphs.

Meanwhile the agricultural industry needs all possible manures and ought not to have to wait till the fisheries are further developed or till excreta are accepted as fertilizer.

155. Mr. V. Govindan (letter of 4th July 1921) objects to prohibition on the ground that the ryots "do not yet understand

the value of this fertilizer," that though where tried it was found "very successful," yet they "were reluctant to buy it on account of its inferior quality due to adulteration and the high price demanded" coupled with the heavy rail freight; he considers that the export "should only be stopped when the fertilizer has become popular in this country," and that at present an export tax of 5 to 10 per cent ad valorem would suffice.

156. It is, however, to be remarked that the high price is really due to the high priced demand by rubber and tea estates, to supply which a single Ceylon merchant takes the bulk of our West Coast fish fertilizers at rates which, as shown in paragraph 144 above, are much above real values; in fact it is stated that the export trade is almost monopolized by this one merchant who buys many thousand tons annually of the various fish manures. This and the extraordinary prices paid for these manures *c.i.f.* Ceylon (see, for instance, paragraphs 144 and 152) show that Indian high prices are due not to the intrinsic manurial value of the manures but to outside competition by the producers of very high priced articles, to supply which rich merchants will pay any price. This may be good for the fisher-folk—though it is probably the middleman who get most of the profit—but is bad for Indian ryots; moreover, the trade seems speculative and unhealthy and is liable to immense fluctuations as shown by the prices of the last four years. Moreover, to wait for prohibition till the ryots recognize the value of the manure is to wait till the Greek Kalends, since, ex-hypothesi, the ryots cannot buy the manure till it is cheap and it cannot be cheap till its export is prohibited or, at least, strongly discouraged by a prohibitive tax. In the end it will be better both for the fisher-folk and for the ryots to have a stable internal demand, free from fluctuations other than those due to lack or abundance of fish, and regulated by proper standards as to quality and freedom from adulteration; indeed, if the market were wholly internal it would be more easy to check adulteration.

CO-OPERATION.

157. Obviously it is easier for petty manufacturers to sell their oil and guano to advantage if they can be got to combine, co-operatively, for such purpose, instead of each petty factory selling its produce independently to middlemen who too often take advantage of necessity to enforce prices unduly low.

Moreover, co-operation will greatly tend to diminish adulteration since, firstly, the society can itself impose and enforce a standard of purity, secondly, it will sell direct in large parcels under a guarantee to big merchants who are above adulteration or direct to large consumers, such as planters, or to the Agricultural Department for subsequent distribution to ryots. The following extract from the Fisheries Report for 1918-19 is relevant:—

"Part of the year was spent in inculcating the advisability of co-operation in the sale of fish oil and guano. There have been and will increasingly be demands for large parcels of oil by arsenals, jute mills, etc., and if the isolated producers—isolated in fact though there may be a dozen in a village—combine as members of a Co-operative Society, it follows that, commanding large parcels, the society can sell to advantage direct to large consumers and thus evade the middlemen, or if they sell through or to a middleman, can fix and obtain equitable prices. Moreover since arsenals and factories, etc., often require high class oil, it will pay the members of a society to manufacture such oil and obtain the consequent better prices. On the other hand the consumer obtains large parcels of even quality in one transaction, and, avoiding the middleman, can give or obtain better terms. With guano it is the same; if societies bulk their products and have them tested, planters, associations, etc., can deal direct for large parcels and can demand a guarantee of quality; this will make for better goods and check adulteration."

In 1918-19 there was one Co-operative Society for the joint sale of fish oil and guano, and in the report for 1919-20 it is mentioned that this society had 36 factories as members which, during the year, made 200 tons of oil, worth Rs. 1,09,100, and 850 tons guano worth about Rs. 85,000, amounts worth attention by buyers. Moreover the Society, as such, was able to borrow considerable amounts for its members. Unfortunately there was insufficient co-operative action in sale owing to inexperience, and want of organization in collecting the products from the various villages; hence sales became individual so that the main purpose of the Society was frustrated. These young societies require the fostering care of Registration and Fisheries officers, especially of the latter who are experts in the actual business—having indeed initiated and fostered it for a dozen years—and know all the details and difficulties not only of manufacture and of sale, but are thoroughly acquainted with the pressure upon individual producers by middlemen and creditors, and with the difficulties of joint action among

the fisher classes. Moreover, if the Agricultural Department would purchase direct from this society it could obtain its present requirements from this single society, and could, by its officers (chemists, etc.), ensure guano free from adulteration and pay an equitable price; this would stimulate the formation of similar societies, and thus, for its further needs, it would obtain a good article at factory prices, supply ryots at minimum prices, encourage co-operative action, and automatically minimize adulteration, which might be taken as any addition of sand or beach-dried manure amounting to above 5 per cent in weight.

PUBLIC HEALTH.

158. Where a fish oil and guano factory is conducted with the utmost care as in using only fresh fish, in rapid steam or other boiling, in working only in proper, well lighted sheds properly floored and thoroughly cleansed immediately after every operation, in drying the guano on proper barbecues, in passing the foul water at once into the sea or otherwise disinfecting deodorizing, and utilizing it, there must always be some annoyance, mainly in odours, to the surrounding public if in proximity to them, since the cooking of fish in large masses and the exposure of the products to the air for drying, must always be attended with noticeable odours. But when factories buy more fish than can be utilized while fresh and do not salt them, so that they become tainted before or during use, when the "factories" are merely existing houses or huts or sheds altered and utilized for the purpose, or cheap "kutcha" sheds, insufficiently lighted or floored, when the operations proceed by day and night, when the fish are dried in backyards or in wrong places on ill-prepared ground, when the foul water is allowed to run into the sand hard-by the factory and houses and there putrify, where cleanliness, if observed at all, is tardy so that the factory building and premises are dirty, odoriferous, and breeding places for flies, and where the factories are placed right among dwellings and in undue numbers, then the nuisance may easily become intolerable. This has been too much the case, as might be expected from the enormously rapid development of "factories"—from nil to over 600 in ten years—operated by petty workers with a minimum of capital, of knowledge, of hygiene, or of civic obligation. Hence a good deal of hostile attention has been paid to the new industry, not always indeed

because of the nuisance but for other reasons such as the raising of the price of fish, factious disputes, and so on; moreover, in some cases the nuisance was in far greater degree due to the drying of unsalted sardines for manure on the beach in the same neighbourhood for miles along the shore, when the nuisance caused by these immense areas of tainted fish was wrongfully attributed to the guano factories. Nevertheless there has been undue and unnecessary nuisance, including the working of undue numbers in populous localities. Consequently a set of by-laws has been drawn up by the local authorities in consultation with the Fisheries Department, and these are given below.

BY-LAWS.

"1. No factory for the manufacture of fish oil or guano shall be set up or worked without a licence from the President of the Taluk Board.

2. The licence shall be in the following form :—

Licence for the manufacture of fish oil and guano.

(This licence will become void if the factory is not erected within six months from the date of this licence.)

THIS LICENCE is granted to of amsam , desam taluk, for the establishment of a factory for the manufacture of fish oil and guano at the site mentioned below and subject to the by-laws of the District Board which are printed overleaf. (By-laws 1 and 3 to 15 to be so printed.)

Taluk.	Amsam.	Desam.	Survey and sub-division number.	Extent.	Boundaries.				Remarks.
					East.	South.	West.	North.	

3. (i) The licence should be renewed annually and will run for the financial year.

(ii) In respect of each licence a fee not exceeding Rs. 10 may be levied by the Taluk Board to cover the costs incidental to the granting or renewing of the licence.

(iii) Application for licence to open newly or to continue the use of fish oil factories shall be made by the owners thereof not less than 60 days before they propose to set up or work the factory respectively.

4. No such factory shall be established in any place other than the foreshore near the sea beach or the margin of a backwater or flowing stream which opens direct into the sea and is subject to tidal action.

Provided that factories on the margin of backwaters or streams must be situated near the opening into the sea.

5. No such factory shall be established close to public thoroughfares, railway stations or other places of public resort, and every such factory shall be situated as far as possible from inhabited houses.

6. If the factory building is not an open shed, it must be lighted and ventilated by doors and windows to the satisfaction of the President of the Taluk Board.

7. The floor of the factory must be properly cemented to the satisfaction of the President of the Taluk Board.

8. Proper arrangements must be made, to the satisfaction of the President of the Taluk Board, for the disposal of the waste water * which remains after the fresh fish have been boiled and

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* See paragraphs 98 -102 *supra*. The effluent water problem is important from a sanitary and economic point of view ; if it is properly treated and utilized not only will any public nuisance be minimized but neighbouring tree and crop growth may be greatly stimulated, as shown at Tanur and elsewhere.

In addition to the remarks on filtering effluent water in the paragraphs mentioned, the following extract from a recent paper by Mr. J. Don before the Institute of Water Engineers is suggestive, in view of the fact that sand is of course everywhere available. " It is well known ", he said, " that filtration through sand not only removes suspended matters and organisms but also produces a marked alteration in the amount of *dissolved* material ". Moreover, " the time required for the purification of polluted liquids, e.g., *sewage effluents*, is extremely brief. *Ordinary sewage is rendered non-putrescible in ten minutes by passage through a ripe filter-bed one metre thick.* The time is too short for bacteria to bring about the change, and it must be concluded that the putrescible matters have been absorbed by the components of the filter ". It is further shown that valuable results are obtained even in unripe filters which have not developed the slimy skin characteristic of mature filters, especially where the filters have been roofed in to exclude light ; " experiments indicate that a sand filter . . . . is capable of absorbing fairly large amounts of ammonia and dissolved organic substances, and that this action takes place rapidly ". Italics are by the present writer.

Further, from a paper by Sir Daniel Hall on Research in Agriculture, printed in the Journal of the Royal Society of Arts for April 1921, the following important paragraph is taken :—

"Some of the principles brought to light in the course of this investigation have been applied with remarkable success to the treatment of sewage. Current processes of handling sewage cannot recover its most valuable constituent, the soluble nitrogen compounds, which are either fermented to destruction or escape in the effluent and cause trouble in the streams. If, however, the crude sewage be passed through a filter bed made up of *straw*, the straw will pick the soluble nitrogen compounds out of the sewage in order to start the humification process. Some 60 per cent of the nitrogen is removed

pressed and the oil skimmed off. Unless the factory owner can satisfy the President of the Taluk Board that such water can be used without offence as a fertilizer for coconut trees in the vicinity, it must be carried by a drain either to a point on the beach just below low water mark or into the backwater or stream as the case may be.

9. Such drain must be constructed of glazed earthenware pipes not less than 4 inches in diameter.

10. The pipes must be laid at such a slope that the waste water shall pass through them rapidly to a proper outfall.

11. The floor of the factory must be flushed daily with water when manufacture is going on and arrangements must be made to the satisfaction of the President of the Taluk Board for such water to escape into the waste water drain.

12. When manufacture is in progress the floor pits and drains of the factory must be disinfected at least twice a week with chloride of lime or some other disinfectant approved by the President of the Taluk Board.

13. The factory premises must be kept clean and free from fish scales or refuse and other organic matter. Effluent water must not be allowed to soak into the soil in the vicinity of the factory buildings.

14. Arrangements must be made for the provision of an ample supply of fresh or sea water for cleaning purposes. If no well is provided the water must be stored in casks or other suitable receptacles in the factory yard to the satisfaction of the President of the Taluk Board.

15. Factory owners shall allow their factories to be inspected by the President, Taluk Board, or any person authorized in writing by him to inspect such factories.

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from the effluent which becomes comparatively harmless, and the straw itself is converted into manure. At Wainfleet this method has been applied, with most promising results, to deal with the sewage from a camp of some 200 men."

The lecturer subsequently pointed out that the sewage must so trickle over the straw that there should, at the same time, be plenty of air passing through the straw filter with the sewage. Probably this would be effected by a somewhat loose packing of the straw in a masonry or other cistern, divided into several connected chambers by vertical partitions but communicating one with the other, so that the fluid should traverse a considerable length of straw filter before its discharge ; this would also prevent undue massing of the wet straw.

It would seem therefore that no serious difficulty should be found in minimizing nuisance or improving the use of effluent water, if the problem is attacked with intelligence and attention.

16. Any person erecting or working a factory without a licence shall be liable on conviction by a Magistrate to a fine not exceeding Rs. 50 and in case of a continuing infringement of this by-law to a fine not exceeding Rs. 10 for every day after notice by the President, Taluk Board, of such infringement.

17. Any licensee infringing any of by-laws Nos. 3 to 14 shall be liable on conviction by a Magistrate to a fine not exceeding Rs. 50 and in case of a continuing infringement to a fine not exceeding Rs. 10 for every day after notice by the President of the Taluk Board of such infringement.

18. No prosecution shall be instituted without the written permission of the President, Taluk Board."

Some of these rules are open to amendment but if carried out by an active, intelligent, instructed staff any nuisance will be largely abated, and many "factories" which either should never have been started or which persist in negligence, will be suppressed. The main object of this bulletin is to suggest better methods, whether technical or sanitary, to instructors, to inspectors, and to manufacturers.

APPENDIX.

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NOTE.

INTERNAL LACQUERING OF TINS FOR JAM.

The following Note was written in reply to a query from a business firm; it embodies experience obtained at the Government Cannery. It forms an *addendum* to paragraph 44 of the Fisheries Bulletin entitled "Remarks on Canning."

2. The "difficulty" mentioned is doubtless the blackening of certain jams with, possibly, the acquirement of a slight chalybeate taste. This is due to the action of the fruit acids on the metal, principally, if not entirely, on the steel of the "tin-plate"; some fruits are particularly acid, and certain of the acids are more active than others in this way; hence the protection of the metal is absolutely necessary.

3. The first thing then, is to *use only tin-plate coated with a full quantity of tin.* It is astonishing what differences exist; some cheap tin-plate is so thinly coated that the least corrosion or hard usage removes the tin and exposes the steel to the action of the acid. Jam manufacturers should specify a high quality coating when ordering tin-plate, of so much pure tin to the square inch. This is the first precaution, without which even lacquering may fail of its full purpose.

4. *Inside lacquering* has long been practised at the Government Fish Cannery for prawns—which are discoloured by naked tin-plate—and fish with vinegar, and it has always been open to enquirers to obtain information there and drawings of the plant. The method is simple enough, viz.—

(1) Obtain a good oil varnish;

(2) Apply it, either as it is, or thinned with turps, or thickened with boiled linseed oil, to the inside of the can;

(3) Bake the can at a certain temperature in a stove;

(4) Repeat the process.

Hence the questions are—

(1) What class of varnish is desirable?

(2) Whether it should be thinned or thickened or even mixed with a solid material or pigment?

(3) What sort of a stove is required and what should be the temperature of stoving?

(4) What methods and precautions are necessary?

5. *Point* 1—*Varnish.*—The object of this class of lacquering is to provide an elastic, durable, fairly solid coating to protect the metal from the acids, etc., and able to stand a temperature above that of boiling water (at Chaliyam of steam at 250° F.), without melting or running; it must also contain no poisonous matter, e.g., lead compounds (white lead, etc.), and have no taste which might spoil the goods. Varnishes are either spirit or oil; that is they contain some "gum" (resin) such as copal, dammar, shellac, etc., dissolved in either spirit or linseed oil. Spirit varnishes are very readily applicable and dry very rapidly, but, by their very composition, they have neither *body* nor *elasticity,* and both of these qualities are essential for our purpose. Hence *only a good oil varnish* must be used. In oil varnishes the resin plays a secondary part; it is the linseed oil which gives the solid, tough, elastic coating, and, indeed, boiled linseed oil may almost be used alone. Hence a varnish containing a *large proportion* of linseed oil is essential. The copal oil-varnish of ordinary commerce, especially with an addition of boiled linseed oil, is well suited, since it consists of boiled linseed oil and a high class "gum" dissolved in it; the ensuing coating, after stoving, has the desired characteristics; it also bears stoving at the necessary temperature. A similar oil-varnish prepared with "dammar" (the resin from the Vateria Indica of the West Coast) is probably cheaper and may be equally good, but has not been tried.

It is advisable to buy the oil-varnish ready made from a *good* maker, so as to secure goods made not only with good material but with all the benefit of experience; much rubbish is sold in India as "varnish" which never dries properly but remains sticky and "tacky." It is *not* advisable to attempt to make the varnishes one's self; it is a rather dangerous business, and requires much knowledge, skill, and experience.

6. *Point* 2—*Dilution of the oil-varnish.*—This is a matter for the canner's judgment. It is common when lacquering to add turps to the commercial article; this renders it easy to work, but thins the coating so that only a very thin layer results. It seems advisable in lacquering cans for the special purpose of resisting fruit acids or marinated articles, to add about 25 or 30 per cent of *thick boiled* linseed oil to the commercial varnish, and then to thin this with turps to allow of ready application to the tin with the brush; the turps soon evaporates from the layer, leaving a fairly

stout layer of oil-varnish. It is possible that with this thicker initial coating, a single coating may suffice, but a second application is invariable at the Chaliyam cannery. One good result from a thick and thorough coating is that the varnish seals up any very slight pin-hole or interstice in the joints of the can, and since, *ex hypothesi*, the coating will resist boiling water, the hermeticity of the seal is more completely assured.

If plain boiled oil is used (without the addition of a gum) as a coating, it should have been so boiled as to be of *very thick* consistency; it should then be thinned with turps to allow of ready application; the turps rapidly evaporates leaving an elastic coating of solid oil. But a resinous varnish is mostly used.

The canners may try the dilution, if any, which suits them, viz., either a thinning with turps, or a thickening with old *boiled linseed* oil, or the commercial article as it is.

It is not necessary to add any solid materials to the varnish which would make it into an "enamel"; such addition would add expense and difficulty, and some materials might even be deleterious.

7. *Point* 3—*Stoving.*—Ordinarily, lacquer is simply allowed to dry, but, for at least two reasons, stoving, that is, drying in a stove or heated chamber at a considerable temperature, is desirable; viz., (1) it hastens the process, (2) it so hardens the lacquer that it will subsequently stand even moist heat, and it is found that lacquer resists destructive influences all the better if stoved (within reasonable limits of course) at a comparatively high temperature and for a long period.

This temperature, for our canning purposes, may be taken as from 250° to 300° F.; it must *not* exceed 300° F. since the goods to be lacquered are soldered cans, and ordinary good solder softens at 320° F., so that the cans would fall to pieces if the temperature appreciably exceeded that degree. The time, usually several hours, depends upon temperature and experience; the lower the temperature the longer the time; the process should result in a hard coating which can barely be scratched, and certainly must not be removable by the finger-nail.

8. *Point* 3—*The stove.*—This is simply a chamber or other receptacle which can be heated so that a moderate *equable* temperature may be continuously maintained; it must be so constructed that each part is equally heated; the temperature should not materially

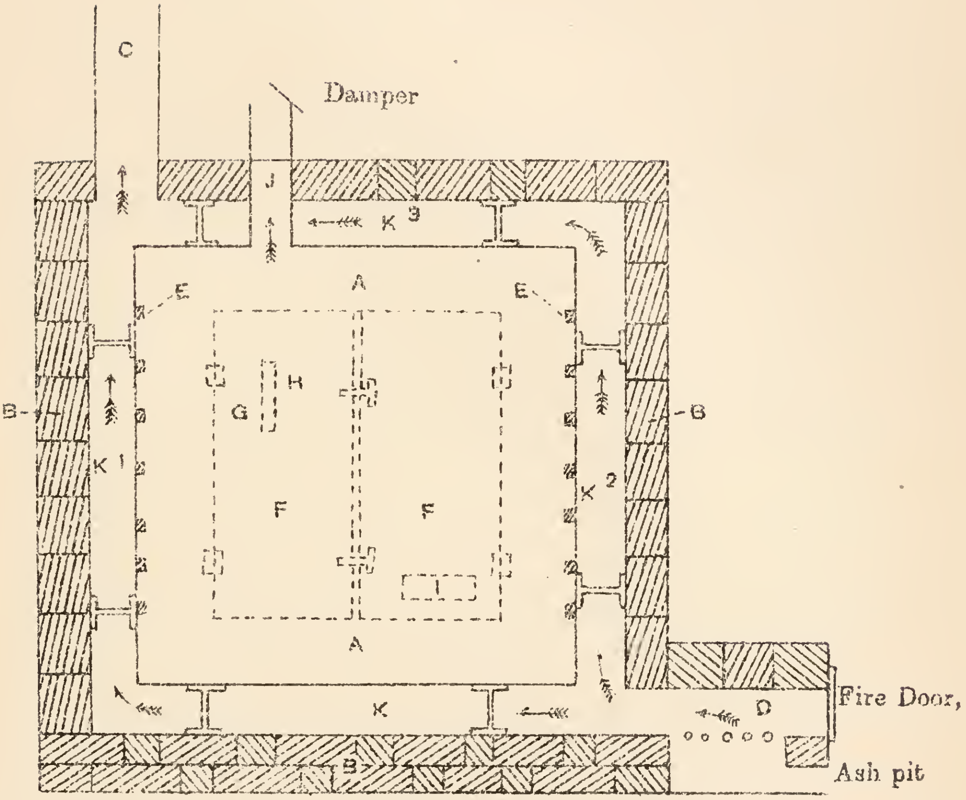
fluctuate; there must be no chance of scorching the lacquer or melting the solder, and any fumes must be allowed to escape. In this country gas is usually out of the question; superheated steam entirely so; either a (wood) fire or the sun must do the work.

A suitable stove is a rectangular chamber of sheet iron, A, set in a somewhat larger masonry chamber, B, in such way that the hot flue gases from the furnace, D, pass through K round every part of A into the chimney C. The heating chamber A may be of any convenient size, with iron battens, E, fixed as ledges on two (or three) sides, and, for heating small cans, about 6 or 7 inches apart vertically; these battens support trays on which the cans are placed. The fourth side has a large iron (double) door, F, fitting closely and provided with a peep-hole G, usually a vertical rectangular slit with a slide; through G, a thermometer H, which must mark up to 400° F., may be inspected. F also has a larger rectangular orifice, I, near the bottom of the door, and fitted with a slide so that air may be admitted if need be, to cool the chamber or to cause a gentle draught for the removal of any fumes through the orifice J at the top of the chamber. A is heated by a furnace D which should be placed at the *side* of the masonry chamber B apart from A, so that the heat of the furnace may not be communicated direct to A as it would be if directly below it, but only indirectly by the flue K and its continuation K-1, K-2, K-3 round the sides of A. The exit J for fumes at the top of A may be led into the side of the chimney C or direct by a short pipe into the open air. A stove of this character has long been in use at the Fish Cannery, Chaliyam, but the furnace D is wrongly placed in that stove; it was intended to remodel this stove so as to serve various purposes. The accompanying sketch is rough, and not to scale, and is merely suggestive; only a vertical section is given.

9. *Solar oven.*—This is the subject of a separate Note. Such an oven is in actual use at Chaliyam, and supplies the required temperature on any sunny day, but will not work on cloudy days. It is at present only a successful experiment, but the lacquered cans at Chaliyam have mostly been stoved in this oven, and the heat costs nothing and cannot be excessive.

10. *Point* 4—*Methods and precautions.*—The first point to be observed is that the cans must be thoroughly cleaned; the varnish adheres better—and this is essential—when the cans are thoroughly free from grease or dirt. The cans should be well washed in

VERTICAL SECTION OF
LACQUERING STOVE



Sketch, not to scale, of general idea of a stove for lacquering cans.
Based on stove actually in use at the Government Fisheries Cannery, Beypore

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boiling water with a little soda ash or washing soda (sodium carbonate) or of caustic soda, dissolved in it; if caustic is used the solution should be very weak. When dry, the varnish should be painted on the tin with a soft brush (badger or camel hair) of sufficient size to enable quick working and to avoid undue streakiness.

The object of adding turps which thins the fluid, is to permit of easy working; thick boiled oil or thick varnish is difficult to apply inside a can, and if very thick its use may not only be uneconomical, but may result in unduly thick and uneven layers, especially at the bottom of the cans. By adding turps working is much easier, and as the turps rapidly evaporates the oil-varnish is left as a moderately thin layer to harden by the heat.

Before putting the cans into the stove the oil-varnish should be somewhat set; otherwise it will run unduly in the stove.

The heat should be applied moderately at first to allow the turps to evaporate gradually; it may then be continuously increased to the required degree.

As stated above, the heat for soldered cans must not rise above 300° F.

When one layer has been applied and stoved, it is usual to repeat the whole process so as to double the layer of stoved lacquer; it is better to give two somewhat thin layers rather than one thick one. In commercial japanning of the better sort five or six thin layers are sometimes given, but this is unnecessary in the lacquering now under consideration.

11. It is of course possible to buy tin-plate in the flat ready lacquered, the lacquer being, on good samples, so adherent and elastic that it does not in the least crack when the tin-plate is bent into cans. But this lacquer is usually thin and, for jam purposes, may be insufficient, though it is used by various jam-making firms even in their export goods. But in such cases it is probable that the tin-plate is specially lacquered, possibly in the jam factory itself.

NOTE.

A SIMPLE FORM OF SOLAR OVEN.

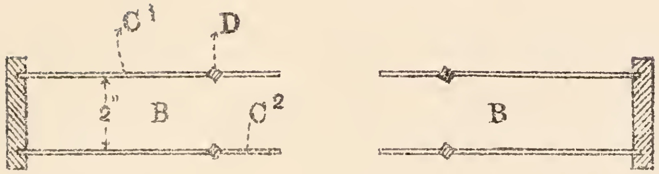
(See paragraph 44 of Bulletin "Remarks on Canning.")

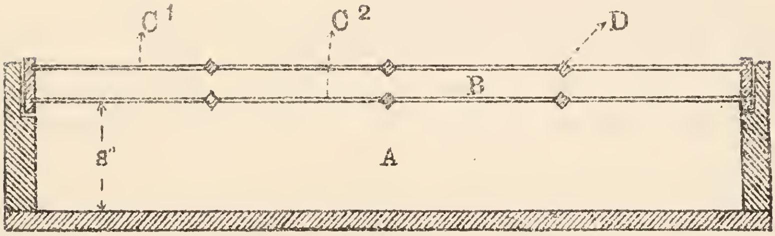
Description.—The "solar oven" or trap consists of a *well-seasoned* teak-wood box (see A in appended sketch of vertical section) of any convenient size, and about 8 inches in depth below the glass sash, the inside being carefully blackened with a dull or dead (matt) black, not a glossy black. The sash consists of a series of glass panes (ordinary window glass) set just like an ordinary window, but double, the panes being separated by a distance of 1½ to 2 inches; see B in sketch of a vertical section. This double sash is the important part of the oven, as it allows the direct rays of the sun to pass freely, but intercepts the rays radiated from the dull black interior, according to a well-known fact in physics; hence the heat is trapped in the oven. The reason for a double sash is not only to duplicate the above effect but to insulate in some degree the heated air in the oven at, say, 250° to 300° F. from the external air at, say, 90°; with a single sash the difference between the temperatures on each side of the single pane would be so great that much heat would be lost not by radiation but by conduction; the stagnant air-cushion between the two sets of glass panes, to some extent prevents loss by conduction. All wood must be thoroughly seasoned so that it may not warp or shrink. Obviously, also, the double sash must fit accurately into the box or there will be great loss by leakage of hot air.

2. *Insulation.*—To prevent further loss by conduction through the walls of the box, this is inserted in an outer box with 3 or 4 inches of insulating packing (sawdust, paddy husk, etc.) between it and the oven; this outer box may be a rough packing case.

3. *Reflectors.*—To increase the internal temperature of the oven, reflectors may be placed outside the oven at such an angle that the sun's perpendicular rays may be thrown into the box; this has not been fully worked out as the heat obtained by a rough arrangement was sufficient for the cannery purpose (baking or "stoving" lacquered tin ware); a couple of small wings of tin plate at the proper angle sufficed.

SOLAR OVEN
VERTICAL SECTION
Not to Scale.

I


II


I = Double Sash, B, with glass panes.

II = Solar Oven, A, of teak, with B in position.

A = Complete Oven.

B = Double glass sash.

C^1 = Upper Series of Glass panes.

C^2 = Lower Series of Glass panes.

D = Wooden battens in which C^1 and C^2 are fixed.

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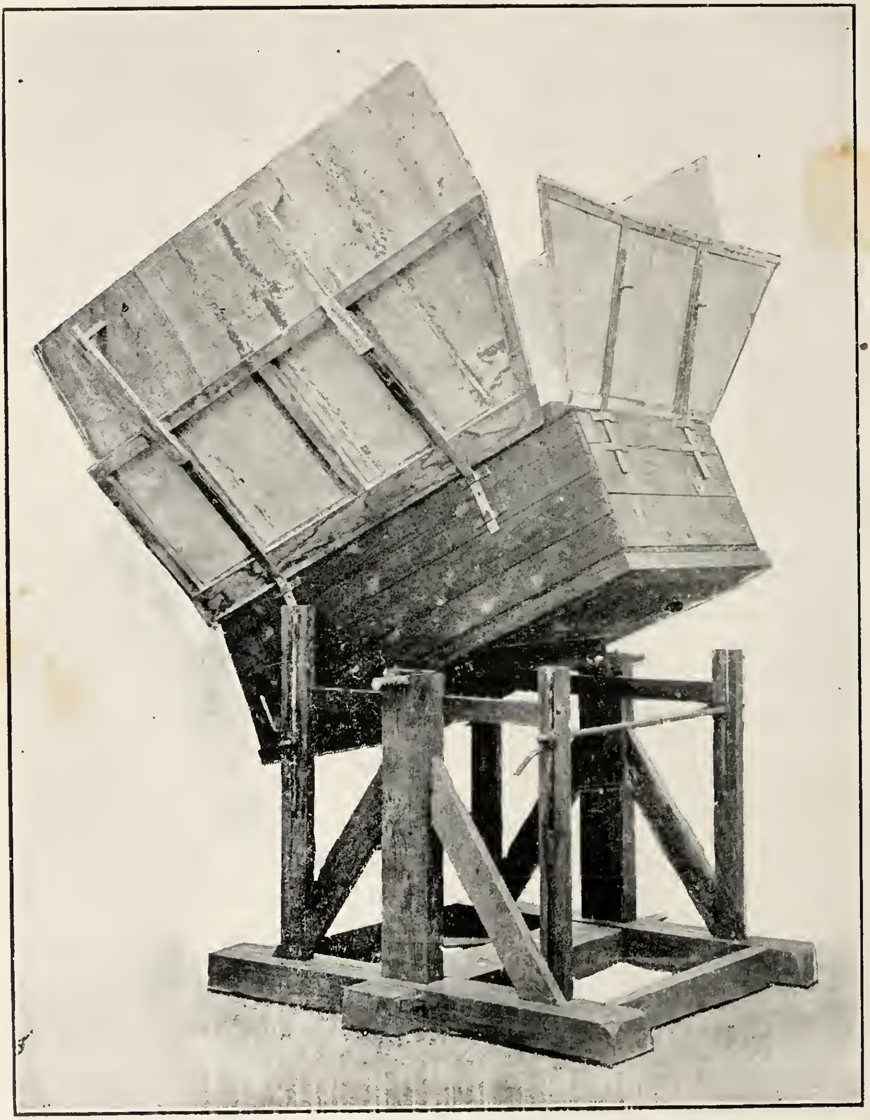
4. *Mounting.*—The oven—see appended photographs—is then mounted so as to insure receipt of the maximum of direct rays; it is obvious that, to avoid *reflection* from the glass surfaces, the sun's rays must always fall as perpendicularly as possible to the glass surface; hence the oven must be so inclinable as to follow the sun; moreover it must face the east till noon and then the west. This is effected by fixing it on a pedestal with a simple inclining arrangement of quadrant pattern, so that every hour or less the surface of the oven may be altered to obtain the necessary perpendicularity of the rays; moreover the whole pedestal revolves on a circular track so that when, near noon, the oven is nearly horizontal facing east, it is revolved so that it now presents its surface to the west. It is found that little practical effect is obtained much before 9 a.m.; after 3 p.m. the internal temperature rapidly falls.

5. *Temperatures obtainable.*—Roughly speaking, the temperature obtained with this simple plant—without extra reflectors—which was not elaborated or perfected for want of time, resources, and need, is double that of the external direct sun heat; that is, if a thermometer placed outside in the *open sun* marks 130° F. the temperature in the oven may be anything from 250° to 280° F. if the oven is properly made, insulated, and attended to; 290° F. was the highest temperature thus obtained in March (vernal equinox) when the outside thermometer marked about 140° F. This, however, was raised to a maximum of 325° F. by a couple of side wings of not very good tin plate.

6. *Uses.*—The oven has solely been used for stoving lacquered tins at, say, 250° F. It is obvious that, in its present form, it cannot be used for evaporative or cooking purposes since the steam would not only cloud the glass but could not be removed without destroying the operation of the oven, which develops temperature by trapping heat in a stagnant, unchanged atmosphere. War difficulties prevented developments which were intended and planned out, and which may yet be taken in hand, viz., the perfecting of the reflecting arrangements and the raising of steam or at least the boiling of water by means of convolutions of thin copper pipes (blackened) passing through such an oven of increased size; such a convolution would be fed from a blackened tank placed in the open sun, and surrounded at a few inches distance by a glass frame so that the temperature of the water in the feed tank may



Photograph of Solar Oven, Chaliyam, showing its mounting.